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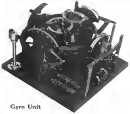

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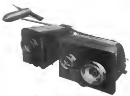

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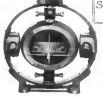

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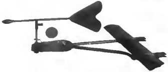

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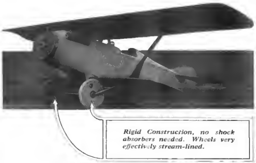

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INDEX TO CONTENTS

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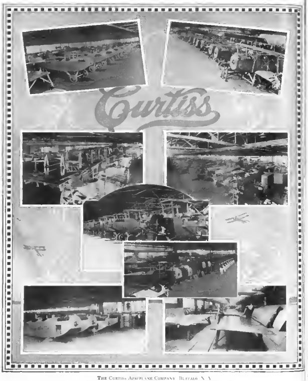

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AVIATION
AND
AERONAUTICAL ENGINEERING

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Massachusetts Institute of Technology

BUSINESS MANAGER
GEORGE NEWBOLD

Vol. II July 15, 1917 No. 12

THE House of Representatives in passing the Army Aviation Bill calling for $640 000,000 has done its part in expediting the aerial program which General Squier has submitted. With but a short discussion the bill was passed amid the cheers of members. It should be noted that the House Committee on Military Affairs, of which Mr. Dent is chairman, sponsored the bill and went over the plans for our air fleet with the leading authorities in Washington. On this committee's recommendation the House passed the bill blindly leaving the whole expenditure in the hands of the President, the Secretary of War and General Squier.

The Senate which usually inquires very closely into bills passed hurriedly by the House, can, from all reports, be relied upon to pass the measure in record time. The President has given his unqualified support, and the appropriation ought to become available within a week or two.

The bill provides that the appropriation covers the fiscal year ending June 30, 1918. So that this vast sum will have to be expended by that time. It is a tribute to the officers who have had a part in drawing up the aviation program which calls for this expenditure, that it was so convincing that the House was willing to take their assurances for its immediate necessity.

The development of aeronautics in this country is at last assured, when for so many years appeals for the proper provision for this arm of the service fell upon deaf ears. There is a tremendous task ahead of the aeronautical industry, which without doubt will rise to the occasion with energy and ability. With the support of the Aircraft Production Board and its broad and far-seeing plans for quantity production, the country may look forward to a realization of the aims and purposes for which these huge sums have been appropriated, at the earliest possible time and with the utmost efficiency.

The Navy Appropriations

Secretary Daniels has asked for $45 000 000 for aeronautics in the Navy. It is probable that his request will be granted and the Navy will be able to begin the expansion of the aerial branch of its service. Evidently the Navy feels that it should be cautious but with the information that is now available regarding the naval uses of seaplanes, flying boats and dirigibles, there will become necessary a development far beyond the present plans.

In the navy the policy of silence may be misconstrued for inaction by those unacquainted with methods of naval bureaucracy. Local papers in various parts of the country have printed news which would indicate that the navy contemplates more activity in aeronautics than has been authoritatively announced.

The establishment of coastal stations for strategic as well as training purposes will help greatly to stimulate activity, for the practical experience gained from the use of aircraft has always broadened the plans of any service.

Italy's Quiet Progress

So much has been written of French, English and German progress in the air that the work of Italy in aeronautics has been overshadowed. Reports now reaching this country indicate that Italy has produced the fastest airplane, the best climber, the largest machine and a fleet of dirigibles which have performed marvelous work along the seacoast.

As submarine chasers the non-rigid dirigible type has been very effective. Italy is placing the greatest reliance on her dirigibles, and it will be well for the United States to profit by her experience.

The secret of Italy's success in aviation is due to the powerful and reliable engines which have been developed. It is asserted that the large Italian engines of 500 700 horse-power have proven that larger airplanes than have been thought possible from an engineering standpoint can be built and flown successfully. To demonstrate this point there is under construction an airplane using 3000 horse-power and designed to carry fifty passengers.

The Aircraft Production Board

Too great credit cannot be given to the members of the Production Board for their unselfish work on behalf of aviation. It will always be recognized as a great piece of constructive planning.

It has been unfortunate that the board has had to operate without its power being definitely understood or defined. It also has suffered because other similar boards have been under attack in Congress. Its powers, functions and authority should be closely defined. The clause in the aviation bill authorizing the board's expenses to be paid was taken out so that the future of the board will have to be carefully considered. The way out of the situation is for the members to accept commissions and in that way become the official purchasing and producing force of the Air Service. By doing this the Army would have in its personnel some of the best business men in the country.

Tests on a Series of Propeller Blade Elements*

By Alexander Klemin

The object of the tests was to provide the designer of aerial propellers with information relative to a series of standard sections, from the thinnest to the thickest in practical use as elements of propeller blades, which might be readily employe

TABLE 1

Table for Dimensions of Sections

[illegible]

Section	Index Ratio		0	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	[illegible]	10
[illegible]	050		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	000
[illegible]	075		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	001
[illegible]	100		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	002
[illegible]	150		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	003
[illegible]	175		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	004
[illegible]	200	Above Below	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	014 000
[illegible]	250	Above Below	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	014 000
[illegible]	300	Above Below	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	016 000

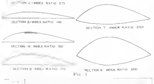
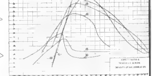


Fig. 1



SECTIONS 1 & 8 HAVE NEGATIVE L/D FOR VALUES SEE TABLE 3

Fig. 2

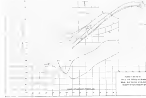


Fig. 3

in making a design in accordance with the Drzewiecki method.

The eight sections were developed on empirical grounds from consideration of a variety of sections and propellers.

The maximum thickness of the first section in the series developed occurs at about 25 per cent of the chord length fr the leading edge, and gradually shifts back as the sect thickens. Experiments on aerofoils, of constant camber w the position of maximum ordinate varied, tend to show tha this maximum is 1/3 of the chord from the leading edge.

The N P L experiments were conducted for one camber how ever, and it does not follow that the same position of maxim thickness would be most suitable for sections of other camb Moreover within the range of angles commonly employed propeller design, 4 to 10 degrees, these experiments show important variation in either K_y or K_x values as the poin of maximum ordinate was varied.

Since in actual practical fairing the maximum thickness necessarily moves back, the above development seems legitima The edges both at leading edge and trailing edge have bee slightly rounded off to correspond with actual propeller desig where a section brought to a sharp edge is liable to breakage.

A series of exponential curves were developed giving the thickness of the section at any point for any ratio of maximum depth/chord These are not readily used however, and are not included. Interpolation between the values given in the tables for the eight sections should be sufficient for all practical purposes.

The index line is the term employed for the length c between the points where the rounding off of the sections begins, as illustrated in sketch under Table 1 The maximum height of the section above the index line is termed h. The ratio $\frac{h}{c}$ is termed the index ratio i, and serves to define any section The development of the sections from the dimensions in Table 1 is sufficiently illustrated by the same sketch

Tables 2 and 3 give the results for K_y, K_x and L/D at various angles of incidence, for both the single cambered and the double cambered surfaces

In Table 4 a comparison is made between the single cambered sections tested, and a series tested by the N P L. The Massachusetts Institute of Technology series seems to be considerably more efficient, but with smaller lift values for the angles of attack commonly used in propeller design and therefore less thrust Where the index ratio is as high as 175, the N P L. section is better aerodynamically This section is so thick, however, that it would be employed near the hub where little load is taken up by the element in any case

In Fig 1 the sections are developed, and in Figs. 2 and 3, the L/D and K_y curves are given for each section for varying angles of incidence

TABLE 2

Single Cambered Surfaces

Aspect Ratio 6. K_y and K_x in pounds sq. feet per foot second

Section		−10°	−8°	−6°	−4°	−2°	0°	1°	2°	4°	6°	8°	10°	12°	16°	18°	20°
1	$K_y\times10{,}000$ $K_x\times10{,}000$ L/D				−1 83 0 42	−0.03 +0 20 0 07	1 76 0 13 7 1[illegible]		1 43 0 23 14 85	5.75 0.33 17 10	7 72 0.48 16 25	9 40 0.65 14 40	10.95 0.95 11 40		12 02 [illegible] 16 1 82	10.58 3 67 2 88	
[illegible]	$K_y\times10{,}000$ $K_x\times10{,}000$ L/D				−1 26 0 53	−0 14 0 48	2 01 0 27 7 54	2 92 0 27 10.95	3.80 0 29 12.90	5 50 0 347 15 85	7 27 0 48 15 15	9 10 0.64 14 20		11.53 1 08 10.70	12 30 2 33 5 30	12.25 3 310 3 90	11 49 3 920 2.94
[illegible]	$K_y\times10{,}000$ $K_x\times10{,}000$ L/D				−0 60 0.435	1 45 0 112 4 65	1 28 0 113 10 71	4 14 0 312 13 25	5 16 0 353 14 60	7 05 0 478 14 80	8 77 0 625 14 00	10.20 0 815 12.80		13 10 1.25 10 45	13 40 2 16 6.20 (?)	12.20 3.40 3.80	11 30 4 02 2 83
[illegible]	$K_y\times10{,}000$ $K_x\times10{,}000$ L/D		−0 181 +0 150	−0 01 0 81	2 12 0 387 3 61	3 74 0 503 7 43	5 60 0 518 10 80	6 47 0 545 11 85	7.23 0.388 12 45	8.86 0 718 12 00	10 40 0 926 11 22	9 30 1 33 6 90	8.05 1.75 4.56				
[illegible]	$K_y\times10{,}000$ $K_x\times10{,}000$ L/D	−0 60 1 81	−0 20 1 34	+0 64 1 06 0 60	2 34 0 86 2 72	1 84 0 80 1 76	5.10 0 82 6.50	5.56 0.91 6 10	4 70 1 10 4 26	4 82 1 32 3 50	3.28 1.47 3 62	6 07 1 74 3 50	6 82 2.00 3 40				

TABLE 3

Double Cambered Surfaces

Aspect Ratio 6 K_y and K_x in pounds/sq. feet/per foot sec

Section		−16	−14	−10	−8	−6	−4°	−2°	0°	1°	2°	4°	6°	8°	10°
[illegible]	$K_y\times10{,}000$ $K_x\times10{,}000$ L/D	2 10		[illegible] 10 1 11 1 4	2 1[illegible] 1 07 1 98	[illegible] 0 70 3 00	1 00 0 65 4 63	4 23 0 63 6 70	5 52 0 66 7 76	2 66 0.71 3 74	2 63 0 90 2 44	2 66 1 28 2.09	3.47 1 49 2 33	4 34 1 73 2 50	5 15 1 67 2.02
[illegible]	$K_y\times10{,}000$ $K_x\times10{,}000$ L/D	2 [illegible] [illegible] 12	[illegible] [illegible] 14	−2 56 [illegible] 00	−7 [illegible] 1 90	−10 4[illegible] 1 81	−6 40 1 71	−[illegible] 04 1 78	−3 90 1,78	−3 33 1 78	−2.96 1,78	−1 54 1,30	−0 50 1.90	0 61 3.14	1 71 2 38
[illegible]	$K_y\times10{,}000$ $K_x\times10{,}000$ L/D	−1 1[illegible] 2 9[illegible]	−[illegible] 50 2 81	−7 1[illegible] [illegible] 78	[illegible] [illegible] 08	−10 1[illegible] 2 [illegible]	−12 90 [illegible] 08	−11 40 2 16	−10 33 2 08	−8 30 2.36	−7 90 2 38	−6 85 [illegible] 38	−3 70 2 41	−4 72 2 34	−3 28 2 74

TABLE 4

Single Cambered Surfaces

Aspect Ratio 6 K_y and K_x in pounds/per sq. feet foot sec

Comparison with N P L. Sections

			2°		4°		6°		8°	
			$K_y\times10{,}000$	L/D	$K_y\times10{,}000$	L/D	$K_y\times10{,}000$	L/D	$K_y\times10{,}000$	L/D
Section 1	Index Ratio Ordinate Chord	05	1 43	14 85	5.75	17 10	7 72	16.25	9 40	14.40
N.P.L. 1		05	1 9[illegible]	13 10	5 75	14 8	7 70	14 10	8 75	13.1
Section 2	Index Ratio Ordinate Chord	075	1 80	12 90	7 30	15,85	7 27	15 15	9 10	14 20
N.P.L. 1		075	[illegible] 90	13 3	17 20	14,10	8 75	13 1	11 80	11,70
Section 3	Index Ratio Ordinate Chord	100	[illegible] 18	14 80	7 05	14 80	8.77	14 00	10 20	12,80
N.P.L. 1		100	6 10	11, 80	8 10	12 8	8 80	12 10	11 40	11 50
Section 4	Index Ratio Ordinate Chord	150	7 27	12 35	8,86	12 00	10,40	10 20	9 30	6 50
N.P.L. 1		150	7 7[illegible]	11,00	8 65	11 40	10,45	10 30	12 35	9 80
Section 5	Index Ratio Ordinate Chord	175	4 70	4 26	4 62	3 50	3 28	3 62	6 07	3 80
N.P.L. 7		17[illegible]	[illegible] 85	6 6	9,85	10 20	11,35	6 70	7 97	5,20

---

* Abstract of a Thesis presented at the Massachusetts Institute of Technology.

The thick double cambered sections show a pronounced negative lift at small angles. This is in accordance with previous experimental results. Considerable care must be exercised in employing such sections. It would seem safer to enclose the center portion of a propeller with a stream-line cowl.

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Notes on Aerial Propellers, by H. Bolas. *British Report* 1911 1912
Luftschrauben untersuchungen by Eberhardt. *Zeitschrift für Flugtechnik*, 1911 1912
Aerofoils with Plane Under Surface and Varying Camber of Upper Surface *British Report* 1911 1912

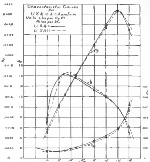
In connection with the Army tests of wing sections, as reported in AVIATION AND AERONAUTICAL ENGINEERING, April 15, 1917, two propeller sections, U S A 10 and U S A 11, were tested. The results are given herewith, both graphically and in tabular form. The values of L/D obtained were comparable with those secured from the very best wing sections, being well above sixteen in both cases. These sections are of such thickness that they would be suitable for use in the other quarter of the blade.

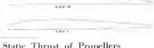
TABLE BY CAMBER FOR U S A 10 AND 11

Distance from leading edge	Camber of upper surface U S A 10	U S A 11
0	0125	0125
0125	0243	0232
025	0343	0321
050	0470	0443
075	0571	0530
100	0632	0586
200	0727	0678
300	0750	0712
400	0745	0706
500	0718	0663
600	0643	0585
700	0538	0500
800	0430	0392
900	0282	0277
1 000	0150	0156

TABLE OF CHARACTERISTICS FOR U S A 10 AND 11

	U S A 10			U S A 11		
Angle	K_y	K_x	L/D	K_y	K_x	L/D
0	000550	0000711	7 73	000490	0000681	7 20
2	001030	0000666	15 50	000985	0000681	14 40
3	001235	0000753	16 40	001220	0000740	16 50
4	001425	0000892	15 98	001400	0000830	16 90
5	001620	0001045	15 50	001390	0001008	13 80
8	002300	0001860	13 28	002190	0001860	11 70
10	002575	0002181	11 80	002540	0002100	12 10
12	002870	0003222	8 90	002850	0002880	9 90
14	002510	0005150	4 90	002580	0004800	5 37





Method of Approximating Static Thrust of Propellers

By Frank W. Caldwell

It is often desirable to know roughly what static thrust a propeller will develop. Computations based on the coefficients of elemental aerofoils are rather involved and do not give a satisfactory analysis of static conditions.

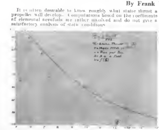


Fig 1

It is thought that it may be possible to estimate the thrust within 15 or 20 per cent by ignoring the width of the blade and the shape of the sections.

The graph in Fig. 1 shows a formula which is based on tests on a number of propellers. The extreme limits are a propeller of 8 ft 6 in. diameter and 10.92 ft. pitch turning at 458 r.p.m., and a propeller of 4 ft diameter and 5 ft 6 in. pitch turning at 1500 r.p.m.

It is desirable to obtain more points for this curve, since the number of propellers tested is rather small. The formula is derived as follows:

Suppose a column of air, whose cross section has an area equal to $\frac{\pi D^2}{4}$ where D is the diameter of the propeller in feet, is set in motion and given a velocity knP where n is the number of revolutions per second, P is the mean pitch and k is a constant for any given propeller. The reaction of such a column of air will be equal to MV. M is equal to $\frac{W}{g}$, which is equal to the density of the air times the area of the column times the velocity of the column. Then M is equal to $\frac{1}{12.4g}\times\frac{\pi D^2}{4}\times knP$. The velocity V is equal to knP. Therefore, the static thrust T, is equal to $\frac{1}{12.4\times 32.2}\times\frac{\pi D^2}{4}\times knP\times knP$. This reduces to the form $T=\frac{(knPD)^2}{508}$.

The value of k was solved for in each case, and the results were plotted against ratio $\frac{P}{D}$.

EDITOR'S NOTE—It is hoped that other engineers will send in similar figures so that further comparisons may be made.

Course in Aerodynamics and Airplane Design

By Alexander Klemin, A.C.G.I., B.Sc., S.M.
Instructor in Aeronautics, Massachusetts Institute of Technology, Member of the Aeronautical Society of Great Britain and Ireland,
and
T. H. Huff, S.B.
Instructor in Aeronautics, Massachusetts Institute of Technology

PART II—SECTION 11

Wing Structure Analysis for Biplanes

There are many difficulties in the analysis of a biplane structure: the distribution of loading between upper and lower planes, the resolution of loading in the planes of the lift truss and the internal bracing, the resolution of loading to give bending moments on the spars, and the alternative methods which may be employed in drawing up the stress diagrams. But in the following notes is developed a system which is now generally employed, and which although it is not rigidly exact,

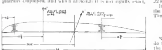


Fig 1

gives sufficiently accurate results for practical needs and as a system of comparison for machines which have been successful in flight.

Distribution Between Planes

The information available regarding distribution of loads between planes is scanty and contradictory. In practice it is sufficient to follow this equation

(1) $W = (A_u x)\frac{11}{9} + A_l x$, where W = gross loading of the machine, A_u = area of upper wing, A_l = area of lower wing, x = gross loading per square foot on lower wing, $\frac{11}{9}x$ = gross loading per square foot on upper wing.

Unless the biplane truss falls away very much indeed from the conventional form, this will be a fair approximation.

Spacing of Wing Spars—Limiting Angles of Incidence

As the angle of incidence of a wing changes its center of pressure moves and accordingly varying loads are placed on the rear and front spars (the center of pressure motion in a biplane is assumed to be identical with that of a monoplane). The spar spacing has to be so arranged that too great a proportion of the load is not thrown on either of the spars within the range of the usual angle of flight. This would be the case were the spars too close together or placed so that one of them would be quite close to one center of pressure. At the same time the spars must not be placed too near either the front or the rear edge, so that there is always sufficient depth of spar. Thus in the machine design of which we are carrying through, the spars are placed as shown in Fig. 1, about 10 per cent from leading edge and about 40 per cent from trailing edge, where the centers of pressure at 0 deg. and at 16 deg. are indicated. The loading is in this case

	Front spar	Rear spar
At 0°	29.8%	70.2%
At 16°	66.6%	33.4%

0 deg. and 16 deg. are taken in our design as the limiting angles of incidence, although very possibly the machine might fly both at some negative angle, and at some angle above 16 deg.

Running Loads

Applying equation (1) where W = 1850 lb. and A_u = 188 sq. ft., A_l = 188 sq. ft. for our machine, we find that the gross loading per square foot on the upper wing is 5.4 lb./sq. ft. and on the lower wing it is 4.43 lb./sq. foot. In the same manner the total gross weight supported by the upper wing is 1020 lb. and the total gross weight supported by the lower wing is 830 lb.

For simplicity, the running load is assumed to be uniform from tip to tip of the wings, and hence the gross running lifts are for a span of 36 ft. 5 in., 28.0 lb./foot on upper wing and 22.8 lb./foot on lower wing.

It is from the gross running lifts per foot that we obtain the running drifts per foot run, by dividing the L/D ratio. Thus we have

	L/D	Upper wing running drift in lb./ft. run	Lower wing running drift in lb./ft. run
At 0°	7.2	3.90	3.18
At 16°	6.02	4.65	3.80

Next it is necessary to determine the net running lift. To do this it is necessary to make assumptions for the weight of the wings and the weight of the interplane bracing.

Thus for the upper wing, assuming a weight of .73 lb./sq. ft., and half the weight of the interplane bracing of 91.5 lb. to be carried by it, we have a net lift of 1020 — 137 — 45.7 = 837.3 lb. or 22.9 lb./ft. run, and for the lower wing 830 — 137 — 45.7 = 647.3 lb. or 17.7 lb./ft. run.

We can now tabulate our results in such form that they can be used in resolving forces in planes of lift trussing and of the wings.

At 0° — Percentage front spar 29.8, Percentage rear spar 70.2

	Upper wing	Lower wing
Gross loading per foot run	28 lb.	22.8 lb.
Drift per ft. run front spar	1.16 lb.	.865 lb.
Drift per ft. run rear spar	2.74 lb.	1.90 lb.
Net lift per ft. run front spar	6.85 lb.	5.30 lb.
Net lift per ft. run rear spar	16.80 lb.	11.2 lb.

At 16° — Percentage front spar 66.6, Percentage rear spar 33.3

	Upper wing	Lower wing
Drift per ft. run front spar	2.70	2.17
Drift per ft. run rear spar	1.35	1.08
Net lift per ft. run front spar	15.20	12.20
Net lift per ft. run rear spar	7.15	6.15

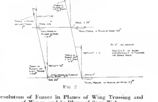


Fig 2

Resolution of Forces in Planes of Wing Trussing and of Wings, and in Plane of Spar Web

In Figs. 2 and 3 are shown the resolutions of forces at 0 deg. and 16 deg. respectively. It will be noticed that the resultant

force in the plane of the wings is decomposed in plane of the spar web. It is this component in the plane of spar web which is subsequently used to draw the bending moment diagrams

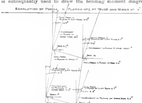


Fig 3

for the spars. This is a slightly arbitrary procedure It would be more accurate to take the force in the plane of the lift truss as producing bending, but there would then be the complication of computing moments of inertia about an axis not perpendicular to the web

From these resolutions it is now possible to tabulate figures which can be employed in the lift truss stress diagram the drift bracing stress diagram, etc.

At 0°

	Upper wing		Lower wing	
	Front spar	Rear spar	Front spar	Rear spar
Force in plane of lift truss/running foot.	7 lb	14 lb	5.8 lb	11.5 lb
Force in plane of wing/running foot	2.4 lb	4.50 lb	1.9 lb	3.7 lb
Force in plane of spar web/running foot.	6.85 lb.	13.8 lb	5.2 lb	11.2 lb

At 16°

	Upper wing		Lower wing	
	Front spar	Rear spar	Front spar	Rear spar
Force in plane of lift truss/running foot.	15.3 lb	8.3 lb	12.6 lb	6.5 lb
Force in plane of wing/running foot	1.1 lb	8.5 lb	1.0 lb	3 lb
Force in plane of spar web/running foot.	15.2 lb	8.1 lb	12.2 lb	6.2 lb

Fig 4

Figs. 2 and 3 indicate some peculiar results Thus at 0 deg., part of the net lift is resolved into the plane of the wing, greatly increasing the demands on the internal wing bracing Were the stagger of the biplane more pronounced, this effect would be still greater, and that is one of the disadvantages of excessive stagger But at 16 deg, in this particular case, the component of the net lift along the plane of the wing relieves the internal wing bracing

Different Methods Employed in Stress Diagrams for Lift Truss

Two distinct methods have been adopted in getting out stress diagrams for the lift truss.

(1) The trussing is treated as if pin jointed throughout by the ordinary bridge truss method, and the bending moments for the spars found as if they were freely supported at the ends, with uniformly distributed loads

(2) The spars are treated as if continuous, so that bending moments in them and reactions at their supports are found by theorem of three moments Then the reactions having been found, the stress diagram is drawn with such reactions as a basis.

The first method has the advantage of simplicity and of giving a very large factor of safety The second method is much more difficult, but probably is nearer the mark, and we shall employ it accordingly.

Bending Moment Diagrams· Theorem of Three Moments

Any good text book on applied mechanics treats fully of the theorem of three moments, so that the following notes will be of the briefest

In Fig 4 is shown a beam loaded with unequal distributed loads over the two spans At the three supports, 0, 1, 2 M_0, M_1, M_2 are corresponding bending moments, R_0, R_1, R_2 are corresponding reactions, $S+_0$, $S-_0$, $S+_1$, $S-_1$; $S+_2$, $S-_2$ are shears on either side of the supports.

If the beam is continuous over the three supports and has the same cross-section throughout, the bending moments at the supports and the loads are connected by the following formula

$$M_1 l_1 + 2(l_1 + l_2) M_0 + M_2 l_2 = -\frac{w_1 l_1^3}{4} - \frac{w_2 l_2^3}{4}$$

All difficulties in working the theory of three moments are due to mistakes in the conventional signs.

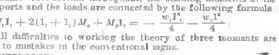


Fig 5

The convention for bending moments is shown in Fig 5. From this follows the rule

Forces to left of a point must tend to turn a beam clockwise about that point in order to give a positive bending moment at that point—anti clockwise to give a negative bending moment

Forces to the right of a point must turn the beam anti clockwise about that point in order to give a positive bending moment at that point—clockwise to give a negative bending moment

Fig 6

If these rules are observed, the effect of the fixing moments is also automatically determined Thus if a fixing moment is found to be negative at a support, and the above rules are followed, its effect will be negative on either side of that support

The convention for shear is shown in Fig 6 If forces to the left of a point tend to shear beam upward, the shear at this point is positive

Observance of this rule is not so important as the observance of the rule for bending moments It is generally easier to see what happens physically.

Working Out of Bending Moment and Shear Diagrams for Upper Rear at 0 Deg.

The principles of the preceding paragraph will be best illustrated by working out the above case fully In Fig 7 is shown the disposition of the wing With a total span of 36 ft. 6 in. and an engine panel of 2 ft 6 in, we allow an overhang of 2 ft 6 in, 7 ft. 9 in for outer span between struts, and a smaller inner span of 6 ft 9 in, which seems a reasonable spacing The loading in plane of spar web as previously found is 13.8 lb./ft run For simplicity's sake, we neglect the engine panel, and loads are taken as acting down for same reason.

To get bending moments at supports

(a) $M_2 = O$ since wing is hinged at engine panel,

(b) $M_1 = -\frac{13.8(2\frac{1}{2})^2}{2} = -43.3$ ft lb. negative in accordance with our rule,

(c) to find M_0 we write $M_1 l_1 + 2(l_1 + l_2) M_0 + M_2 l_2 = -\frac{1}{4} w_1 l_1^3 - \frac{1}{4} w_2 l_2^3$, from which M_0 becomes 80.5 ft lb

To get shears at supports

(a) $S-_1 = (2\frac{1}{2})(13.8) = 34.4$ lb Therefore $S-_1 = 34.4$,

(b) Taking moments about support 1 we have $M_0 + S+_1 l_1 - \frac{W_1 l_1^2}{2} = M_0$, $-43.3 + S+_1(7.75) - \frac{13.8(7.75)^2}{2} = -80.5$ therefore $S+_1 = 48.7$;

(c) Taking moments about support 2 we have $M_0 - \frac{w_1 l^2}{2} + S-_0 l_1 = M_1$; $-80.5 - \frac{13.8(7.75)^2}{2} + S-_0(7.75) = 43.3$ $S-_0 = 58.0$;

(d) Taking moments about support 1, we have $M_0 - \frac{w_2 l^2}{2} + S-_2 l_2 = M_0$, or $-\frac{13.8(6.75)^2}{2} + S-_2(6.75) = -80.5$ $S-_2 = 34.6$

To get reactions, we have

$$S-_1 + S+_1 = R_1 = 83.1$$
$$S-_0 + S+_0 = R_0 = 116.5$$
$$S-_2 = R_2 = 34.6$$

After having found bending moments, shears and reactions at supports, it is very easy to draw the entire bending moment diagram by finding points of zero shear and maximum bending moment

Thus in outer span, if x is distance to right of Support 2 of point of zero shear, $S+_1 = xw_1$ and $x = \frac{48.7}{13.8} = 3.52$ ft

Bending moment at this point is (taking forces to left) $M_x = -\frac{w_1 x^2}{2} + S+_1 x = 42.2$ ft lb

Similarly in inner span if x = distance to right of support O of point of zero shear $S+_0 = xw_2$ and $x = 4.25$.

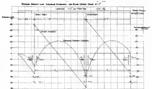


Fig 7

Bending moment at this point is (taking faces to left) $M_x = -\frac{w_2 x_2}{2} S+_0 x = 43.5$ ft. lb.

These points having been found, the bending moment diagram can be sketched in

References

"Wing Data and Analysis for a Staggered Biplane by Dr. A F. Zahm, Franklin Institute, December 1914

British Report 1912-1913 No 83 A preliminary note on methods of calculation which may be employed in the determination of the stresses in the spars of airplane wings by Bairstow and MacLachlan.

Syllabus of Lectures on Meteorology Given in the Course in Aeronautical Engineering at the Massachusetts Institute of Technology in Cooperation with Harvard University

Part I

Ten Lectures by Robert De C. Ward, Professor of Climatology, Harvard University

Introductory

Importance of Meteorology in aviation, aircraft and weather in war:

(a) General climate;

(b) Weather and weather forecasts, military field meteorological services.

The Atmosphere

Composition, height, "Troposphere" and "Stratosphere", general characteristics of each

Temperatures in the Free Air

Vertical temperature gradients temperatures at various heights, inversions, stable and unstable conditions in relation to flying

Pressure

Importance, comparison with water, decrease with altitude, physiological effects of diminished pressure, measurement, mercurial and aneroid barometers and barographs use, errors, corrections, determination of altitudes by means of barometers, isobars; pressure gradients.

The Wind in Relation to Pressure at Earth's Surface

Wind direction, deflection of winds from gradient· earth's rotation and friction, cyclonic and anticyclonic wind systems, "Gradient Wind", Buys Ballot's Law isobaric types Wind velocity, general relation to gradient Beaufort Scale and its equivalents in force, and in velocity in miles an hour, Anemometers Robinson and Dines; gustiness of wind.

Conditions of the Atmosphere Affecting Aviation

General and Local· (a) General air movements, essentially horizontal, atmospheric layers and waves. (b) Local convectional currents, essentially vertical, due to thermal controls, causes and conditions (c) Effects of topography upon air movements, combining both horizontal and vertical elements, due to mechanical controls, effects of friction, topography, and character of surface, vertical and horizontal movements in general in relation to flight.

Weather Forecasting

Explanation of daily weather map, principles of forecasting explained by reference to type maps, for United States and for Europe, general characteristics of cyclones and anticyclones, tracks, velocities of progression.

Non-Instrumental Local Forecasts

Barometric tendency, veering and backing winds, changes in wind velocity, weather proverbs

Clouds

Types, cloud classification, methods of determining cloud heights and velocities, and results, value as weather prognostics, fair and wet weather clouds; fog, special consideration of cumulus and cumulo-nimbus.

Forecasts of Wind Velocity and Direction Aloft

Direct observation by means of pilot balloons, kites and cloud movements, directions of cloud movements in cyclonic and anticyclonic systems in the United States and in Europe, estimates based on surface conditions and on general knowledge of upper air currents, "gradient wind", diurnal variation in wind velocity and direction, changes due to progression of cyclones and anticyclones; wind and cloud direction and night flying.

Favorable and Unfavorable Weather for Flying

Wind, clouds, haze, etc.

Part II

Laboratory Work at Blue Hill Observatory (10 hours); Alexander G. McAdie, Abbott Lawrence Rotch Professor of Meteorology. Harvard University, and Director of the Blue Hill Meteorological Observatory, Readville, Mass.

Psychological Aspects of Aeronautics

By Harold E. Burtt, Ph.D

During the past year there has been in progress in the Harvard Psychological Laboratory a study of certain psychological aspects of aviation. Experiments upon the first problem as to the delicacy of perception of changes in equilibrium in various directions have already been recounted.* It was found that a change of equilibrium in a lateral direction (roll) is generally perceived much more readily than in a longitudinal direction (pitch), and the possible practical implication of this fact in the selection or arrangement of airplane controls was noted. The following is an account of the study of a related problem—the comparative rapidity of reaction to sudden changes of equilibrium with various types of airplane control.

It seemed possible from theoretical considerations that a reaction with a dep control, for example might involve a mental and motor attitude appreciably different from that involved in a reaction with a stick control. In banking the wings, the wheel warp and the lateral motion of the stick employ quite different muscular performances, and consequently different regions of the brain governing the muscles, and even in controlling pitch, the use of two hands and of one hand in moving the control backward and forward are two distinctly different operations. It was suspected that an aviator might actually react more quickly when making one form of motion than when making another. Accordingly, this hypothesis was subjected to the experimental test.

Apparatus Used in the Tests

The same apparatus was used as in the earlier work. The subject on whom the experiments were performed sat on a chair upon a square platform which rocked on a rounded plate a foot below its center and was held in a horizontal position by heavy spiral springs attached from its four corners to the floor. Wire ropes from the corners passed through pulleys directly below and were attached to short chains, each of which passed over a sprocket on the same shaft with a ratchet. Heavy spiral springs on the other ends of these chains could be placed under tension by a crank and worm gear on their upper end, while the lower end was held by the ratchet. When this ratchet was released, the tension of the spring took up the given wire rope and quickly lowered the desired corner of the platform. Thus the person sitting on the platform could be tilted suddenly in any of the four directions, left, right, front or back.

A dep and a stick control were mounted on this platform in front of the chair on which the subject sat. The dimensions of three and their location with reference to the position of the person operating them followed the standard army specifications. A foot bar was also placed at the regulation distance. The controls were both arranged so that a very slight movement of either broke an electric contact. This contact and another made by the ratchet and its pawl actuated a device which measured time to fiftieths of a second.

The individual sitting on the platform in the same bodily position he would be in an airplane could thus be suddenly tilted in one of four directions. He then reacted as quickly as possible with the given control, just as he would when an airplane was tilted by a puff of wind. If he tipped to the right, he warped the wheel clockwise or moved the stick to the right and vice versa. If he tipped forward he pulled the wheel or stick toward him, and vice versa. Trials with dep and with stick were intermixed in irregular orders to avoid any practice effect influencing the results. The actual time that elapsed between the instant the platform started to tip and the beginning of the movement of the control by the subject was accurately measured for a large number of reactions under the various conditions. Five individuals participated in the experiments some fifteen hours apiece.

Prior to the actual experiments in which the subjects were instructed in which manner to react, each was given a chance to react to the sudden tip in the manner that "seemed most natural to him." In these first reactions, four of the five subjects moved the control toward the high side of the platform. It is interesting to note the instinctive tendency to react toward the high side, the form of reaction that has been adopted in standard airplane controls.

The results of the investigation of this problem are negative. Nothing in the nature of the dep as contrasted with the stick control facilitates or retards the speed of reaction. It seems to be rather a question of the amount of muscular force necessary to move the lever. Thus averaging the results for the five subjects on lateral movement (roll), when a force of approximately 7 lb. on either control is necessary to break the contact, the average reaction times with the dep and with the stick are very nearly the same. There are minor variations in both directions, but the average difference (including plus and minus values) is less than 1 per cent. When, however, the dep requires a force of 4 lb. and the stick a force of 10 lb., the average reaction times with the dep are 16 per cent quicker. And when the dep requires 12 lb. and the stick 4 lb., the reactions with the latter are 9 per cent quicker. That is, the control possessing the greater inertia yields a slower reaction time, but when the forces required to move the dep and the stick are approximately equal, there is little difference in the speed of reaction. A similar result is found with longitudinal motion. When both controls require about 5 lb. force to break the contact the difference in reaction times is slight, averaging only about 2 per cent.

The result is thus evident that from the standpoint of efficient action with dep as contrasted with stick controls psychological factors do not play a part. Reactions to a sudden change of equilibrium are equally rapid with both types of control when there is no difference in the force required to overcome the inertia of the mechanism. Where such differences in force are required, the reaction time with the control possessing the greater inertia is the slower.

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[*] Aviation and Aeronautical Engineering, April 1, 1917, p. 218. A technical account of the entire research will be published later in one of the current psychological periodicals.

Aeronautical Patents

Copies of these patents may be obtained for five cents each by addressing the "Commissioner of Patents, Washington, D. C."

ISSUED JUNE 12, 1917

1,229,502. Filed August 28, 1916. To Knute W. Olson, St. Paul, Minn. Safety Device for Aviators.

1,229,297. Filed July 21, 1916. To Geo. Lehberger, Newark, N. J. Undercarriage or Chassis for Flying Machines.

1,230,045. Filed Feb. 25, 1913. To Vlastimir Skrivanek, Ft. Wayne, Ind. Flying Machine.

1,229,410. Filed Jan. 4, 1916. To John R. Campbell, Austin, Tex. Airplane.

1,229,713. Filed Apr. 24, 1915. To Geo. A. Chaddock, Broad Green, Liverpool, Eng. Mechanical Air-Borne Ship.

1,229,649. Filed Feb. 20, 1917. To Lafayette Pace, LaFollette, Tenn. Safety Appliance for Airplanes.

JUNE 26, 1917

1,231,387. Filed Apr. 4, 1916. To Joseph H. F. Laflamme and Omer Gravel, Toronto, Ont., Canada. Bomb Dropper.

1,231,881. Filed Mar. 9, 1917. To Isaac Francis Taylor, E. Dulwich, London, Eng., assignor of one-half to Samuel Peck, London, Eng. Aerial Apparatus for Defense against Hostile Aircraft and for Other Purposes.

1,231,444. To Hulet William Springer, Springfield, Ill. Wing or Propeller for Aerial Dynamics and other purposes.

Airplane Dopes

By Gustavus J. Esselen, Jr

The development of the airplane has been so rapid that it is natural for one to assume that the present methods of wing manufacture were coeval with the airplane itself. Yet it is only about six years ago that the more prominent German manufacturers first experimented, in a practical way, with the methods at present in use. At that time they were using for their wing covering cotton or silk, oiled or varnished or some of the various rubberized fabrics which had been adapted from balloon manufacture. None of these were satisfactory. Some presented difficulties in getting them sufficiently taut, some of the fabrics had been weakened in the coating process, and all were more or less affected by the oil and gasoline from the motors. It was not long, therefore, before the general superiority of the methods of to-day was demonstrated.

Fabrics

Before considering in detail these modern methods and the dopes used in them, it may be well to look briefly into the matter of wing fabrics, because the behavior of any given dope depends, to a considerable degree, on the fabric, and on the treatment which that fabric has undergone previous to the application of the dope. At present the fabric most in demand is linen, because of its strength and the toughness and difficulty with which it tears. Owing, however, to the present scarcity of linen, specially woven cotton fabrics are coming on the market. The chief drawbacks to these cotton fabrics at present are the comparative ease with which they tear, especially when once started, and the fact that they do not take the dope so well as linen. It is not unreasonable to hope, however, that dopes will be compounded to work as well on cotton as the present ones do on linen. The weight of the linen in use varies from 3½ to 4¾ ounces per sq. yd., and the tensile strength ranges from 60 to 100 pounds per inch, depending somewhat upon the weight. As for the cotton fabrics, they weigh from about 1½ to 4 ounces per sq. yd. and the tensile strength varies anywhere from 25 to 80 lb. per inch. As a general rule, those fabrics are chosen which have about the same strength in the direction of the warp as in that of the filler.

The general procedure in making up a wing is so well known as to require little comment. A linen or cotton fabric is applied to the wing frame, and then several coats of a suitable dope are applied. The chief function of the dope is to tighten up the fabric and give a smooth, taut surface resistant to the weather, and preferably also to oil and gasoline. It also adds materially to the tensile strength, the increase ranging from 10 per cent to 50 or 60 per cent, depending upon the fabric used, and how much the fabric has been stretched before doping. Further reference will be made to this last point later.

Relative Inflammability of Dopes

The dopes which are at present in use may be divided into two classes, first, those made from a base of cellulose nitrate or pyroxylin, and second, those made with a cellulose acetate base. In either case, the base is dissolved in a suitable solvent, and often some substances are added to preserve the flexibility of the coating or to modify the shrinkage. These added substances are, in other words, somewhat analogous to the camphor in celluloid. The great outstanding difference between cellulose acetate and cellulose nitrate dopes is the inflammability of the latter, a difference which will probably be emphasized more and more as the use of airplanes for peaceful purposes increases. On the other hand, the initial cost of cellulose acetate dopes is somewhat greater than that of pyroxylin dopes. Some manufacturers have found a happy medium in applying three coats of pyroxylin and finishing with two or three coats of acetate. This gives a fire-resisting surface, even though the coating is not non-inflammable all the way through. To give an idea of the relative behavior of the coatings left by the two types of dope, the concrete example of the application of a lighted match to a finished wing may be cited. In the case where an acetate dope has been used, the fabric is not ignited until the coating has melted or charred away. However, with pyroxylin, the coating itself starts to burn at once, and in turn sets fire to the cloth. Still more striking is the fact that two drops of gasoline can be put on a small piece of fabric coated with a cellulose acetate dope, and allowed to burn, without causing any injury to the fabric. The same test applied to a pyroxylin-coated cloth, however, results in the immediate ignition of the coating, which sets fire to the cloth as before. From the point of view of resistance to fire, therefore, cellulose acetate dopes are much safer.

When we come to consider the actual doping of wings, we find almost as many methods as there are different concerns in the business. Some engineers prefer to stretch the fabric as tight as possible on the frame, and apply a dope of only slight shrinkage power; others stretch the fabric less taut, and rely more on the shrink of the dope; while still others adopt an intermediate course. This is probably because up to the present very little scientific attention has been paid to the doping. Most of it has gone along by rule of thumb.

Properties of a Good Wing Surface

There is, however, practical unanimity as to what constitutes a good wing surface after it is dry. In the first place, it must, of course, be smooth. A very appropriate measure of the smoothness is given by the wind resistance. Measurements of this value have been made by Zahm,[1] by Gibbons,[2] and several others. It has been found that taking plate glass as the standard, doped or varnished wing surfaces have a wind resistance of not over 1.2. Such materials as wire gauze or singed cotton have wind resistances between 1.35 and 1.70. Unsinged cotton may go even higher. As to the effect of variation of speed, for very smooth surfaces, such as plate glass and doped wings, the surface friction varies as the 1.8-1.85 power of the velocity. As a general rule, the rougher the surface, the higher the exponent, which reaches 2 for surfaces with nap. (Gibbons[2] has pointed out that there are exceptions.) An interesting calculation has been made by Gibbons,[2] in which he shows that the difference in resistance between an uncoated fabric, such as unsinged cotton and plate glass, amounts to 0.013 lb. per sq. ft. at 70 m.p.h. He figures that in a large machine this would amount to a total head resistance of about 18 lb., or 150-180 lb. decrease in lifting power.

The next quality a good surface should possess is that it should adhere well to the fabric. The reason for this is obvious. In case of an accident causing a break in the cloth, it ought not to be possible to start the coating and peel it off. The surface should furthermore be taut, and should be waterproof and unaffected by gasoline or oil. The value of water-resistance speaks for itself. A moment's consideration of the amount of gasoline and oil which gets on the wings of an airplane in service is sufficient to convince one of the necessity of resistance to gasoline and oil. If further argument were needed, it would only be necessary to recall that some of the earlier fabric coatings had to be rejected because they lacked this property.

It has just been remarked that the wing surface should be taut, or, in other words, should not sag. On the other hand, it is desirable that the wing should yield, to a certain extent, under a load. In this way the stress will be reduced and the surface may stand, whereas an unyielding surface might break. Gibbons and Smith[3] have shown that a convenient way to get an idea of the relative value of this property of "give," or, as they term it, the "efficiency," is to measure the area under the stress—elongation curve for a given sized piece of fabric. This, of course, represents the work necessary to break the fabric. They took pieces twelve inches long and one inch wide, and measured the stretch as the load increased. In general, it was found that the stretch up to a load of about 20 lb. was greater with uncoated, than with coated, fabrics. That is, with uncoated fabrics there seemed to be a certain slack which was taken up at first under light loads, and, as soon as that was taken up, the stretching proceeded more slowly. Furthermore, it was found that linen coated under no tension gave a much greater elongation than linen coated under tension. In some cases it required two and one-half times as much work

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[1] *Phil. Mag.* VIII, 58 (1904).

[2] *Report of Nat. Advisory Com. for Aeronautics for 1916*, pp. 178 ff.

[3] *Report of Nat. Advisory Com. on Aeronautics for 1916*, pp. 143, 154 ff.

to break linen coated under no tension as to break the same linen uncoated. On the other hand, the work required to break a piece of linen coated under tension was about the same as that needed to break the uncoated linen, and that in spite of the fact that the coated linen seemed to have a higher tensile strength. In other words, uncoated linen and linen coated under tension have about the same "efficiency," but linen coated under no tension has an "efficiency" about two and one-half times as great. As has already been mentioned, it is the usual practice to stretch the fabric somewhat on the frame before drying, the degree of stretching varying with the individual plant. In view of these results, however, it is recommended to stretch the fabric as little as possible. Then, in case of an accidental blow to the wing, the increased elongation will tend to reduce the stress, and if the stress is not too great, save the wing from injury.

Methods of Obtaining a Good Wing Surface

With this discussion of the desirable properties of wing surfaces in mind, the next question is as to the methods employed in the dope room to obtain these qualities. In the first place, smoothness. The smoother the fabric to start with, of course, the easier to get a smooth surface. The ordinary nap, however, is easily taken care of by the dope. Given a suitable fabric, precautions should obviously be taken to keep dirt away from the dope before it is used, and from the wings before they are dry. As a rule, from four to six coats of dope are applied, and in some plants, in order to obtain proper smoothness, each coat is sand-papered before the next one is applied. It has been found good practice to work the first coat well into the fabric in order to ensure the maximum adhesion. Subsequent coats it is well to brush out more, although the last coat may be applied heavier if desirable, from the point of view of build up.

When one comes to discuss the matter of adhering to the fabric, dopes are often blamed where the fault lies in the sizing of the cloth. As a general thing, dopes do not penetrate well on sized fabrics. There are exceptions to this rule, and the explanation may be that in those cases where dopes do penetrate well on sized fabrics, the particular sizing involved is soluble in the solvent of the dope. Another factor which probably enters in, is the character of the solution which constitutes the dope. The indications are that the more nearly the dope approaches to being a true solution, the greater the penetration, whereas the more colloidal it is, the less it will penetrate. For any given dope, it has been demonstrated that it will penetrate better, adhere better, resist atmospheric conditions better, and wear better in every way, when applied on an unsized fabric, than it will on the same fabric sized. A reasonable way of accounting for this is to assume that where there is no sizing, the dope penetrates the fibres of the fabric rather than merely between the fibres, and thus when dry it is almost a part of the fibre. Since most sizing can readily be removed by boiling either in plain water or a weakly alkaline solution, it is a simple matter to insure good adhesion.

As to tautness, very little need be said. All dopes of today render the surface taut, and it is possible to obtain dopes which give much or little shrinkage at the fancy of the engineer in charge. All dopes are also waterproof, but the extent to which they resist the continued action of water, such, for example, as exposure to the weather in a rainy period, varies with the dope. The writer has seen test panels exposed to three months of spring weather from which the dope had almost all disintegrated. This, of course, was a very extreme case. On the other hand, one of the leading manufacturers exhibited one of their machines at the Aero Show in New York last February, just after it had seen six weeks' service on the North Atlantic seaboard during the height of winter. In addition to being subject to the ordinary rigorous conditions of this time of the year, this machine had returned from its last trip covered with ice, and yet the wings were still in good condition. This particular machine had been doped with a cellulose acetate dope, and then given one or two coats of spar varnish. It is the general practice with some companies to finish with spar varnish, this being used to make the surface more waterproof. The use of spar varnish has one disadvantage, however, and that is in the matter of patching. As a rule, a hole in a wing can be patched with a piece of fabric by using dope as a glue. On spar varnish, however, most dopes do not stick, so that in order to make a repair the varnish has to be removed first.

There is one bane of the dope room which has not yet been mentioned, and that is the formation of white spots. These occur more frequently with pyroxylin dopes than with acetate dopes. They are due to moisture condensation during the drying, and show up, as a rule, only on humid or rainy days. They can be removed by going over them with a little solvent, or, better, by applying a cellulose acetate dope designed for the purpose, which leaves a fire resisting surface, as well as removing the white spots. Of course, the white spots can be prevented, even on damp days, by regulating the amount of moisture in the air of the dope room, but this, as a rule, requires a rather elaborate ventilating system.

Covering Power

One question that is of interest to the manufacturer is, "What is the covering power of this or that dope?" It is almost impossible to answer this question categorically, because of the personal equation that enters in, and because of the difference in behavior of different fabrics. A given dope contains so much solid (or non volatile) matter per gallon, and will, therefore, cover much or little surface, according as it is applied, thick or thin. However, different dopes with the same weight of solids per gallon may vary in their covering power when this is measured by the amount necessary to give a proper surface on any particular fabric. In view of these complicating factors the best that can be said is that, in general, dopes cover from about two and one half to five square yards per gallon, when applied so as to give a suitable surface themselves, without any finishing coat, such as spar varnish. This may be accomplished with from four to six coats according to the individual practice but, in any case, the weight of the resulting coating for a given dope and degree of finish will be approximately the same. This weight ranges from one and one-half to about three and one-half ounces to the square yard.

Durability

Another question which is of immediate interest is that of the length of time that a good wing surface will last and this, too, is very difficult to answer with any exactness. The chief determining factor in this case is the dope itself, although there are conditions which have already been considered which affect the wearing qualities of wing surfaces somewhat. Some results are given in the *Report of the National Advisory Committee for Aeronautics for 1916* which indicate that, in general, cellulose acetate dopes are far superior to cellulose nitrate dopes for use on cotton, that is the decrease in tensile strength of the doped fabric on exposure to the weather is much less with acetate than with nitrate dopes. The same seems to be, in general, true for linen, but not in so marked a degree.

In testing dopes, it is customary to make up test panels and expose them to the continuous action of the weather. This, of course, is much more severe treatment than airplanes ordinarily receive. The first desirable property to disappear is usually the flexibility and the length of time before this happens can therefore be taken as a measure of the relative value of different dopes. Because of the wide variations in atmospheric conditions with the season of the year and the locality, it is not possible to give any definite length of time as a standard during which a dope should not show marked signs of deterioration. The best that can be said is that in general practice it is found necessary to redope wings every three or five months.

While not coming strictly under the head of "dopes," it may be of interest to refer briefly to the transparent, non-inflammable wings which have been reported in the press as being used in certain instances abroad. The material in question is made from cellulose acetate. In a thickness of .010 of an inch, this material weighs nine ounces per square yard, and has a tensile strength of about 72 lb. per inch. It is claimed that an airplane with wings of this material is almost invisible at a height of a few thousand feet. In any case, it is obvious that the field of vision of the pilot would be much increased. One difficulty with these sheets is that, when once started, they tear very readily. A patent has been taken out for remedying this difficulty by reinforcing the transparent sheet by means of a fabric, such as silk, woven rather loosely. While it may not have any great tensile strength of its own, it serves to arrest any tearing which may get started. It has the disadvantage, however, over the clear material, that the fibres must interfere with the more extended view of the operator.

Kapok—And Some of Its Uses

By Charles Garrison

Kapok is the name given the fibre which envelops the seeds in the pods of the tropical trees of the *Bombax* family. The pods are about the size and shape of our common milkweed and the down has a similar silky lustre.

Kapok has many interesting characteristics not found in other fibres. Of these its great buoyancy and resilience are of special value. The fibres are short and smooth, have thin walls and contain a large amount of air, probably the largest amount found in any fibre. They are also oily, giving them a water-resisting quality.

The Bombax family is widely distributed in tropical countries but the species which has the buoyant and resilient qualities in the highest degree is the *Ceiba Pentandra*. The word *Ceiba* means "canoe" since the natives use the trunks of these trees in the same manner as Robinson Crusoe did. *Pentandra* refers to the five fold plan of the flower.

Trees of this species are found wild in many places, but the best qualities are those cultivated on the island of Java. Many fine plantations are to be found there where the process of selection has made the product very uniform and valuable. The United States is trying to encourage the culture of kapok in the Philippines but so little care has been given to selective cultivation, that the quality is much inferior to that grown in Java.

As the uses for kapok increase other grades find their way to market from India, Cochin-China, Peru, Ecuador, Mexico, etc. These uses are limited at present to but a few industries. Mattresses hold the first place in volume, since they are cheaper and lighter when filled with kapok than with hair or cotton. Undoubtedly the most important use is for life-saving purposes. Coats, vests, and other garments are lined with this material in such a manner that the wearer cannot sink. Such clothing is neither cumbersome nor bulky and its buoyant qualities are permanent.

Air filled life preservers are unreliable and cork is clumsy, heavy, and in time becomes dangerous as it disintegrates and loses all its virtue. At present for life saving purposes, air filled preservers are not approved and cork preservers are fast giving place to kapok.

The making of kapok fabrics has been attempted in many places, but it has attained a commercial importance only in Germany, as far as the writer knows. In France this has also been accomplished but in a more experimental way. The fibres are very straight, and slippery and they vary greatly in length, just the qualities that make them difficult to spin. Fig. 1 shows a magnified kapok fibre, while Fig. 2 shows one of cotton. You will at once note the absence of "hooks" or twists in the kapok which are necessary for one fibre to cling to another.

FIG 1

Kapok is really not so simple as it looks and its buoyancy depends on many things. Among these are its natural quality, its treatment before use, and the manner of its application. The writer has conducted a large number of tests during the past three years in the laboratory of the Kapo Mfg. Co., and has discovered many facts hitherto unknown. Fig. 3 represents a test recently made under the supervision of the U. S. Steamboat Inspection Service. The horizontal axis represents time given both in hours and days, the vertical axis represents the buoyancy in pounds of dead weight supported.

It is noteworthy that there is a sharp decline of the curve during the first few hours and a more gradual decline later. These are from different reuses. After 24 hours immersion the life preserver sustained over 20 lb. of weight per pound of kapok. This is a good record, under exceptional conditions, 25 lb. may be attained.

Another life preserver containing the same amount of fibre, but made by those who do not understand its application thoroughly, sustained but 12 lb. of dead weight per pound of kapok, the conditions of the tests being the same in each case. Kapok fibre per se has only about one-half the buoyant value usually attributed to it, the balance being due to special contributing conditions.

FIG 2

In time the fibre attains total saturation, but after drying there is a partial recovery, the permanent loss being largely due to the removal of the natural oil. In one test with half a pound of the fibre total saturation occurred after an immersion of 93 days.

In a series of tests with a garment immersed for an hour each working day, covering a period of four months, or 108 immersions, the maximum loss of buoyancy was less than 7 per cent.

In aviation three uses are found for kapok. The more common is the garments made for the use of aviators. Besides the buoyant quality, they have warmth, the kapok being an excellent insulator.

The other use is on the machine itself. Rodman Wanamaker's "America" was provided with kapok mattresses for the furnishing of the cork-pit.

At present kapok floats are also being designed for the "blimps," illustrated in AVIATION AND AERONAUTICAL ENGINEERING for March 1. These are two cigar shaped receptacles each containing about fifteen pounds of specially prepared kapok, being some seven feet long and eighteen inches in diameter. These are covered with heavy waterproof canvas and are secured to the skids in four places, so that they are held with sufficient rigidity to withstand the air pressure. The coverings and straps for each of the floats would weigh about ten pounds, making the total weight of the pair fifty pounds. They would sustain the required weight of six hundred pounds for many hours.

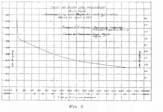

FIG 3

Testing Altitude Instruments

During May 100 instruments for measuring altitude, or speed of ascent, were submitted for test to the Bureau of Standards, Department of Commerce. These included ordinary aneroids, altigraphs, and ratanoscopes, and were mainly from the Army and Navy. The number of altitude instruments actually tested during the month was 121. The average rate of arrival of altitude instruments during the calendar year 1916 was 12 per month. The Bureau endeavors to give immediate and unofficial reports on the tests of these instruments.

Extracts from Inspectors' Manual Aviation Section, Signal Corps, U.S.A.

General Remarks on Inspection

Inspectors will bear in mind the fact that the Government specifies material of a definite quality and it is the duty of the inspector to make certain that material fully meets requirements

Army inspectors will examine only such material as has been in some way clearly indicated as inspected by the manufacturers' inspectors.

No parts rejected by inspectors will be used in any assembly intended for Government use except by written authority from the Office of the Chief Signal Officer

An inspector will exercise a general supervision over raw material received at the factory and likely to be used for the Government

Following the production and acceptance of a machine of any type, complete working drawings will be furnished by the manufacturer to the inspector All other machines of this type will be made in accordance therewith and no departures therefrom permitted without written authority from the Office of the Chief Signal Officer

It is understood that the manufacturer may try out in the sample machine experimental features, but that in all other machines built under the same contract there will be no experimental design, material, or workmanship

Material proved defective may be rejected at any time in the course of manufacture or assembly, even though having already been passed by an inspector

It is understood that the manufacturer reserves the right to reject any material or parts already accepted by the Government inspector if such rejection is approved by the Government inspector

The Engineering Division of the Signal Corps has assigned Signal Corps numbers to all airplanes, engines, and propellers on order for the Aviation Section of the Army

Name Plates

It is desired that when these plates are applied they should be close to the surface and be bedded in shellac to keep anything from getting back of same and also to keep them from being pulled off Fasten with escutcheon pins about 1/16 diameter and ¼ inch or ⅜ inch long.

If applied to metal parts, bed in shellac or air drying Japan for the reason as stated above Drill hole for escutcheon pins the same size as pins and flatten pin slightly to be sure they will hold

Marking of Number Plates

A set of steel dies, consisting of letters and figures, has been furnished inspectors for use in marking all material accepted for the Signal Corps. Whenever it is required to use such letters or dies, this office directs that the wording and notation to be put on the number plates which have been furnished for material ordered be placed there only by the United States Army inspectors and under the direction of the senior inspector at each factory This applies to number plates already furnished by this office for engines as well as any other number plates that may be furnished in future

Engine Tests

The question has arisen as to how thorough a retest of an engine should be in case of failure during the investigation test or the six-hour test

It is not desired to submit the manufacturer to unnecessary expense in this connection, but it is desired to ascertain beyond doubt whether or not the engine is really a serviceable engine for airplane usage

As a general rule it is safe to state that the failure of any vital part should be followed by complete retest of engine This is subject to modifications in accordance with the following illustrations

Assume the failure of a valve spring It is due to one of three things—design, material, or workmanship. It should be the duty of the inspector to discover by a practical method in which class this failure may be If due to design it can be only determined by repeated tests. If any continuous test is interrupted by valve springs it is a suspicious circumstance, and the following procedure will probably discover whether it is due to design or material. Take other valve springs at random Break them in any convenient manner If the grain of the steel at the fracture is coarsely crystalline in all of them, then it is fair to presume that all the valve springs of the entire lot are defective and that the steel has been improperly heat treated or tempered If, on the other hand, the grain of the steel shows a fine grain fracture, characteristic of good valve spring steel, then it is probable that repeated failure is due to improper design If the inspector finds that the springs are either faulty in design or material there is no use in calling for repeated tests until a new lot of springs is obtained

procedure shows a good grain spring steel and in the opinion of the inspector the design is good, the failure was probably due to accidental causes and the springs may be replaced and the test continued without complete retest

In cases of this kind, where the inspector is in doubt samples of the broken part should be submitted to this office, where analysis or further examination may be made to determine the real cause of the trouble

In cases of failure of magneto, it may be due to the magneto itself or to the magneto drive, which may transmit to the magneto stresses and shocks that should not be possible in connection with good engineering design

Where the inspector feels that the design is at fault, he should so report and with his report submit detailed blue prints or sketches of conditions existing, if possible, and suggestions for improvements

In case of failure of bearings, trouble may be due to lubricating system being designed wrong, or to accidental failure of it The inspector should be able to discriminate and to know whether retest is necessary

(C) Harris & Ewing

MAJOR HENRY SOUTHER, CHIEF AIRCRAFT ENGINEERING DIVISION

An engine with an improper lubricating system will fail repeatedly, and retest will be called for if the inspector suspects this cause of failure. If the failure is proven to be accidental, then only such a portion of retest should be demanded as inspector considers necessary

It is not desirable to enumerate all details that may fail, but if failures are handled in the above suggested manner, a reasonable conclusion should be possible and one that will at all times be fair to the manufacturer and at the same time protect the Government against all defective engines

So far as possible in connection with engine tests, observations shall be taken in accordance with standards adopted by the Society of Automotive Engineers

The following suggestions should be adhered to as closely as possible in reference to Specification 1002, Section No 11, investigation test. These suggestions do not refer to final acceptance test, which will be covered later The inspector or inspectors viewing the investigation test should bear in mind the fact that the engine to be tested is a finished product, and no vital parts will be allowed to be changed during the continuance of the run The following adjustments will be considered permissible

Gaskets may be replaced only once, one complete set of spark plugs may be substituted two valve springs may be replaced, water, oil or gas leaks may be remedied, pumps may be adjusted, carburetors may be adjusted, magnetos may be adjusted valve timing may be adjusted

Other replacements will not be permissible during this or the final acceptance test Time required to make any of the above adjustments should be added to the total time of run

Inspectors will submit detailed reports on such tests to this office, and it is suggested that they make frequent notations as to the test proceedings

The following should receive close attention by inspectors during the final acceptance test of six hours (Re Specification 1002, Sec 11) This test is to be given every engine built for the Government before being accepted by the Army inspectors The entire test should be run at the maximum horse power at rated revolutions per minute of the engine and only such adjustments as are given under investigation tests will be permitted without an entirely new run of the engine

When the engine is disassembled after this run the inspector should view every part liable to breakage or wear, and in case of excessive wear should insist on replacement of the part When such replacement involves a vital part, such as a piston, bearing, or cylinder, the engine should be returned to the stand and entire retest made over After this retest the engine should be disassembled and inspected as before

The final-hour test is to be made on every engine sold to the Government and on a suitable dynamometer The engine should never develop less than 4 per cent of its maximum horse-power at any time during the run Inspectors should take their own readings and assure themselves that the engine is up to specifications in every detail It is recommended that in addition the engine be run at 300 to 400 revolutions per minute for at least 10 minutes and then the throttle to be opened quickly to ascertain if carburetor is adjusted properly and that all cylinders are firing at low engine speeds

Inspection of Cylinders

1 Cylinder jackets should be tested for leaks while submerged in water with air pressure Pressure to be at least twice that of normal water pressure

2 Cylinder bore should be checked carefully at four points both top and bottom for being out of round for being over or above tolerance in size and for finish of bore

3 Cylinder studs must be of proper height and square with surface

4 Valve seats should be inspected for uniform width and lining

5 Valves after being ground in a gasoline tight seat should be inspected for leaks in three positions approximately 120 deg apart without removing the gasoline from the case

6 Valve springs should be of specified strength and when compressed should not be compressed more than drawing limits

7 All valve mechanism should be inspected for workmanship

8 Intake manifolds are inspected internally and externally for workmanship surfaces of manifold joints and valve cage joints must be true and of good surface These surfaces should be checked on surface plate

Inspection of Crank Case Upper Half

1 Check distances from center line of crank shaft to deck both front and back and between crank shaft and cam shaft

2 Check distances from each end of cam shaft to top of deck and on V type engines to both decks

3 Check cylinder centers also bore of cylinder holes

4 Check cam follower guide holes for centers against cam shaft cam centers

5 Check thrust bearing bore for size

6 Check all studs for center hole placement alinement threads, and all tapped holes for threads with plug gauge

7 Check cam shaft bearing to main bearing for size, alinement, and condition of bore

8 Check magneto boring bore for distance from cam shaft and size

9 Examine case for sand holes gas holes and defects such as shifting of cores

10 Measure the thickness of all walls and decks

Inspection of Crank Case Lower Half

1 Inspect lower case for center distances of oil and water pumps

2 Inspect for oil leaks when filled with kerosene

3 Joints of upper and lower case should be good fit

4 Check location of gear cover holes and surfaces.

Inspection of Crank Shafts

1 Stamp manufacturer's number and S C number on shaft
2 Measure each bearing at four points 90 deg apart
3 Measure thrust bearing
4 Measure gear bearings and ends.
5 Key taper and spline
6 Propeller hub thread
7 Thrust bearing thread
8 Try bored hole for starter
9 Try width of throws.
10 Try width of bearings
11 Measure length dimensions
12 Try all holes for location and size
13 Examine for checks and flaws
14 Try bearings for run out
15 Scleroscope test for quality of steel usually about 40 52.
16 Inspect and measure taper with great care
17 Inspect and measure spline or keys with great care
18 Inspect and check threads with plug gauge
19 Examine running and standing balance
20 Inspect holes and threads for oil system in shaft
21 Make oil pressure test for leaks in oil system

Inspection of Cam Shaft

1 Cam shafts should be tested for hardness by both Brinell and Scleroscope tests.

2 Shafts should be set up in centers and each cam tested for opening and closing points, neutral period, amount of opening, size and condition of bearing surfaces, and distance between cams

3 Ground surfaces should be inspected for finish

4 Keyways should be inspected for placement

Inspection of Spur Gears

1 Engine spur gears should be inspected while running on their own centers with two-thousandths back lash This includes only spur gears.

2 Engine bevels should have six thousandths back lash and are inspected on their own centers

Inspection of Engine

The following questions should receive the inspector's approval before he passes the engine for Government use

Is engine fastened down properly when assembled in machine?
Are all connections made in the most approved manner?
Is carburetor adjusted properly?
Is oil pump working O K and is oil pressure good?
Are valves timed right and do valve stems have proper clearance?
Do valve stems have safety pin to prevent valve dropping in cylinder in case valve spring washer pin breaks?
Does engine have good compression?
Is cam shaft in proper alinement so that valves on all cylinders open at their proper relative time? (This should be checked carefully before cylinders are put on case and should be kept within close limits.)
Is there any suspicious noise to be heard at any engine speed?
Are any of the valve springs weak?
Do rocker arms hit valve stems squarely?
Are push rods bent or do they bind in any way?
Is propeller tight on crank shaft or jack shaft?
Are there any leaks in gas manifold water manifolds, exhaust manifolds, oil pipes or air line?
Does engine function properly at low speeds as well as high and with quickly opened throttle?
Has engine any bad "rough" point?

Inspection of Cable Wire, Turnbuckles, and Fittings

CABLE.

Are there any kinks in the cable?
Are loops properly made?
Are thimbles used in eyes?
Are ends wrapped properly (wrap must be at least 15 times diameter)
No splicing of cable is permitted
Has acid eaten cable during soldering?
Are any of the strands broken?
Are wrapped ends stream lined and show the result of skilled workmanship?

ROEBLING HARD WIRE

Are there any file cuts or flaws to weaken it?
Is loop well made?
Is ferrule put on correctly?
Are there any sharp bends or kinks?
Are wires too loose or tight in machine?

FITTINGS

Is workmanship good?
Is material good?
Are holes drilled correctly to develop proper strength?
Are there any deep file cuts or flaws to weaken it?
Is rivet or pin fastening wire put in properly?
Are thimbles of large enough diameter?

TURNBUCKLES

Any file cuts, tool marks or flaws in shanks or barrel?
Are there too many threads exposed?
Is turnbuckle of right strength and size to develop full strength of wire?
Are shanks bent?
Are threads on shank or in barrel well made?
Is barrel cracked?
Is turnbuckle properly wired (see sketch under "Approved Method of Wiring Turnbuckles")?

(To be continued.)

A Three Years' Flying Experience*

By Capt. B. C. Hucks, R.F.C.

The past three years, although normally a short space of time, yet measured by the advance of aviation, has been a veritable lifetime Many thousands of people are now deeply engrossed in the subject. Most of you who have honored me with your presence here to-night have studied flying from the very highly technical and scientific side, in fact far too technical and scientific for me, and you certainly know a great deal more about the subject from that point of view than I do I hope that this plain, non technical account of things, hardly touching upon the war, connected with my flying which have been brought to my notice during these three years may interest you a little and perhaps form the basis of a discussion

I think I am right in saying that through the war aviation has advanced more than it would have done in eight or ten years of peace conditions. In fact the rate of improvement in aircraft is so fast the pace so alarmingly rapid, that it is almost impossible for manufacturers to keep pace, for it seems that by the time the latest and most efficient type of machine is manufactured in sufficiently large numbers to gratify half the requirements of the services that type is out of date and obsolete

Progress Owing to the War

That you may realize at a glance the remarkable strides that have been made over this period I will show you some diagrams which, without giving any figures that may be military secrets, should convey a fair idea how the capabilities of aircraft have improved. I have taken the average performances of five different types of service machines used at the beginning of the war and compared them with the average performances of five different types of late patterns now in use in France


Decorating Two French Aviators on the Somme Front

The first diagram represented the growth in three years of the maximum speed capacity flying level The second diagram consisted of two curves showing the increase in machines' capacity for climbing against time The next diagram represented the growth of horse-power developed by aero engines. And lastly, the increase in the number of certified pilots during the past three years.

A pilot has only to take a short flight on a 1914 type machine and then fly the latest 1917 pattern as a comparison to really appreciate this colossal advance

Some little time ago I had occasion to again fly after a considerable lapse of time, a 50 h.p Gnome Blériot, a one-time premier machine, in fact a type used quite a lot by ourselves and the French at the very beginning of the war. At first I believed the machine to be a very bad specimen of the species but ultimately, after flying it for some time and acquiring a sort of lost art of balance, like a skater who has not skated on ice for years and has to get his legs again I realized that it was quite a good specimen of the type, but that it takes quite a time to again get used to such inefficiency The advance seems to have been along, one might say, quite conventional lines that is, improvements on what might be accepted as standard designs and no good results have been obtained from any departure from that standard Perhaps the furthermost departure from what I call standard, and that is very slight has been the triplane The results obtained with the quadroplane have not justified the experiment

The Inherently Stable Machine

During the past three years the first marked improvement to my mind, which asserted itself was the inherently stable machine, attained apparently by such slight detail alterations as sections of planes and elevators that it required an experienced eye to detect a stable or unstable airplane by casual inspection when standing together Then came the synchronized timing gun gear, which enabled the machine guns to be fired through the propeller on tractor machines This device is really so simple that one is at a loss to understand why it had remained so long undiscovered It had the effect of giving the tractor type of machine a new lease of life, although a more efficient aerodynamically than the pusher it had been falling into disfavor as a fighter on account of the inability of the pilot to shoot straight ahead of the machine

Improvements in engines, to my mind, are responsible for present-day performances to a far greater extent than improvements in machines, chiefly through sheer increase of horse-power And cases have occurred where certain obsolete types have been made serviceable simply by fitting an improved type of engine.

The improvements in the machines themselves seem to have been limited to details, such as wing sections attention to head resistance soundness of construction, etc

The very efficient freak machine has yet to make its appearance

I will not attempt to discuss the future of aviation, but setting aside the boundless commercial possibilities, I am more and more convinced that if we find it necessary to keep up an enormous navy say a two-Power standard to protect our island it will be essential to maintain at least the same standard in the air That in itself guarantees a colossal future for aeronautics

But to return to the subject of my paper to-night, I would like to place before you a few points as I have found them during a further three years of piloting

Difference in Machines

I have flown many different types of airplanes, and considering the extraordinary variations in the types the difference in the actual piloting of any modern machine, to my mind, is remarkably small I am of the opinion that a pilot who is thoroughly efficient with any particular type will in a very short time be master of any

I find that on stepping out of a very fast small scout into a really big twin engine machine the difference in the manner of piloting is very slight compared with the vast difference in the machines Precisely the same methods are employed, the same troubles and risks are to be avoided the chief characteristics seem to be that the smaller and faster machines are more difficult to land but are easier to handle in the air In the case of "crashes" the larger and heavier the airplane the less damage is likely to occur to the occupants as a tremendous amount of the impact is absorbed by the machine. Very much larger and heavier machines than those at present in use might be comfortably flown single-handed, no extra effort being required for the controls, provided the controlling surfaces are properly balanced

To the lay mind it might appear that with such contrasts in the outward appearance of the smaller and larger machines, it would be necessary to train pilots specially and extensively for each type, but in my experience this is not so I certainly think the best results are obtained when pilots are allowed to specialize This, however, I understand has many drawbacks on active service

Crashes are mainly due to three causes, viz— engine failure, faulty piloting, and faulty machines.

Engine Failure

Engine failure undoubtedly is responsible for most of the crashes, often because of the hopeless unsuitability of the landing ground at the pilot's disposal To many pilots engine failure is most disconcerting, and it is then they are called upon to use rather more judgment and skill in that even with a fairly suitable landing ground available they very often crash In my experience, embracing the testing of hundreds of new machines it is seldom that a serious defect in the engine "lets one down," it is nearly always due to a small detail I think I have had to make more forced landings through failure of the petrol supply than all the other troubles combined This is due more often to failure of the pressure feed than to a choke in the supply pipes and very seldom to severed connections in the feed system

Because of the absence of a float chamber to the carburetor in the rotary engine even a variation of the gasoline pressure is more serious than in the rigid stationary type In the former case the amount of gasoline that gets to the engine is controlled by the pressure and a fine adjustment If the pressure increases unduly, the engine chokes from overrichness of mixture on the other hand if the pressure drops away the mixture is unduly weakened This variation can be controlled by the fine adjustment to a large extent, but when that limit is exceeded the engine will fail Most of the trouble seems to be caused by failure of the pump which in some cases forms an integral part of and is driven by the engine in others it is a separate unit driven by a small air-screw These failures are usually through valves sticking up and pistons becoming dry. Other causes of failure are in the relief valve not being pressure tight or sticking down At any rate the present system of pressure feed to my mind is such a bugbear that it is high time something was substituted

As far as the non-rotary engine is concerned, to my knowledge this matter is being tackled I have been flying recently a machine fitted with a gasoline pump in place of the air pressure pump the gasoline being pumped direct from the main tank to the carburetors and the surplus is returned to the tank through an adjustable spring loaded relief valve so that gasoline is delivered at any desired pressure to the engine So far it has proved most satisfactory, with this advantage that a punctured tank does not put it out of action Dirt in the gasoline tank accounts for quite a large proportion of engine failures in new machines This form of trouble ought to be avoided It is an important matter which manufacturers should be made to recognize, and a very thorough system of tank washing employed before installation in the machines

The dirt in the tank usually takes some time to work its way into and accumulate in the feed pipes or filters sufficiently to choke them The machines are often by that time being delivered by air by pilots who are none too familiar with them consequently engine failure means a good chance of crashing

I remember having four forced landings while delivering a new B.E.2C from Farnborough to Dover on this account Another simple cause of engine failure which might easily be guarded against is that gasoline cocks in many cases have no definite locking device to insure that they remain in the open position during flight, consequently they are liable to vibrate into the "off" position thus cutting off suddenly the gasoline supply Many instances have come to my notice where gasoline cocks are fitted in such a manner that the tendency is, through the weight of the cock lever, to fall shut instead of the reverse This is such a simple and yet such an important point that it really is surprising mistakes like this are continually allowed to be made I have had engines cut out suddenly on three occasions during the past two months from this cause alone; one meant a forced landing because the gasoline cock was not accessible to the pilot, the other two were opened again in the air It often leads to serious results, as the gasoline fails suddenly and it is seldom that the cause is discovered before the forced landing is made. Having a somewhat limited time at my disposal this evening I will not touch on what I have found to be other causes of engine failures, but I can assure you that as far as my experience shows they are a small proportion compared with those due to gasoline supply, and improvements in this direction will reduce engine failures enormously

Faulty Piloting

Errors of judgment or faulty piloting account for nearly or perhaps as many crashes as engine failure

The most common error made even by experienced pilots is losing flying speed on a turn which starts a side-slip, and given sufficient height terminates in a nose dive or the more serious predicament, a spin This mistake is often made under the stress of circumstances when engine failure calls forth extra effort on the part of the pilot to reach a certain landing spot The trouble is nearly always incurred by turning too flatly until the wing drops and the machine side-slips, generally in the effort to get into more suitable ground than that available straight ahead This is always a dangerous manoeuvre, and in nine cases out of ten when smashes have resulted probably less damage would have been caused had the pilot kept his machine from turning and pancaked straight ahead I have found that most of the later type machines can be stalled (i.e., speed reduced well below flying speed) without any risk of side-slipping provided they are kept in a straight course and laterally level as they will automatically drop the nose as soon as the speed becomes so low that the elevators have little or no effect. Most of the serious accidents start at a height insufficient for the machine to get out of its side slip before striking the ground Others strike the ground at the later stage usually a nose dive but in some cases a spin If sufficient height remains after the machine assumes a nose dive there is no reason why it should not be pulled out and a normal glide resumed but in the other event, although it is possible to get out of a spin, it is far more difficult a proposition than the instinctive maneuvre of pulling up out of a nose dive

A spin is the extraordinary turning movement that some machines only too readily take up after being stalled on a turn or being turned too flatly even with plenty of flying speed This is due to the machine suddenly meeting the air a great deal out of the parallel with its longitudinal axis either through side-slipping, skidding or yawing in the air Having had more than one involuntary spin but having been fortunate enough to have sufficient height to get out again, I feel the matter is not to be treated too lightly The position a machine assumes in a spin is a rapidly revolving side-slip or a fairly steep spiral dive, with this rather serious drawback that the more one tries to pull it up by means of the elevator the faster it spins No matter how high one is, if one persists in trying to pull it out in a normal way, it will remain out of control because the elevator has now become the rudder and instead of pulling it out, increases the speed of turning If the controls are abandoned, the machine will come out of its own accord, but personally I have always found the best and quickest remedy for spins is to straighten the rudder and shove the joy-stick forward; a clean nose-dive will then result out of which the machine can be pulled.

I think in the matter of spins, prevention is better than cure, and it is up to the designers to see that their machine is of the non spinning type, as however clever and quick the pilot may be in applying his pet remedy, he may not have height enough to do so, and the results are usually disastrous

The errors of judgment which are made in landing account for crashes galore but these fortunately, are usually a small matter compared to those made in the air, seldom resulting in more than a smashed landing chassis Flying experience is the only remedy for this particular fault

Landing with the wind will sometimes end in a crash through the machine overrunning the limit of the landing ground, whilst landing side to wind will buckle wheels and wreck chassis Neither of these troubles is always the direct fault of the pilot.

An easily distinguishable standard type wind vane on every recognized landing ground would considerably lessen crashes from these causes.

Faulty Construction

Accidents directly due to faulty construction of the airplane are, fortunately, comparatively rare, as when they happen the results are so often fatal They occur, however even on standard types In some cases the airplane is not entirely at fault, as in these days of heavy high speed efficient machines with so little head resistance and which attain colossal speeds on diving, it is such an easy matter for the pilot to increase the load beyond the highest factors of safety One has only to consider the load on the wings of a machine dived at 160 m.p.h. when it is pulled out with a heavy hand

Constructional failures of machines in the air can sometimes be traced to damage inflicted by imperfect landing usually to the back part of the body in the region of the tail skid This gets overlooked and subsequently the tail gives way under any extra stress whilst flying

I should like here to be permitted to make a suggestion for the consideration of our chairman for what it is worth i.e., that a detailed record be kept of every engine failure forced landing or accident of every kind and description that happens, at any rate, at all home stations These records to be collected and classified so that valuable data may always be available However some such system as this may already be in operation

I now come to a few points which might be brought forward from my experience with instruction of pilots

Medical Tests for Prospective Pilots

I think that a great deal of time and expense might be saved if some form of medical test were applied to prospective pilots such as I understand is done in France where the effect of sudden shocks upon the system of the candidate is recorded by mechanical means, and other tests are made which are supposed to give a fair indication at once of the medical fitness and the possession of the necessary qualities, such as nerve, judgment, and the presence of mind required for the making of a pilot

There are many pupils on whom a lot of time and material has been wasted in the endeavor to make pilots of them who simply do not possess these ordinary qualities, and it is not until they have had smash after smash that it is discovered they simply have not got it in them Now

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* Paper read before the Aeronautical Society of Great Britain.

the French method should weed out the non suitable candidate beforehand

Personally I consider that the nearest equivalent to the art of flying is that of motor-car driving, a person who thoroughly understands and who can drive a car really well should possess the qualities required for piloting an airplane. General Brancker, in the paper he read a short time ago before the Society, mentioned a good horseman as the type possessing the necessary qualifications. I agree that good hands, a good head, steady nerves and judgment are essential qualities all of which should be found in a good motorist, with this advantage that the good motorist is more likely to be naturally mechanical a faculty inborn and not easily acquired, and so important in the matter of flying.

Types of Airplanes for Instruction

Time and material would be saved in my opinion, if the modified "penguin" type of machine were more generally used for the very earliest training. I refer to the small powered machine incapable of leaving the ground but designed solely for taxi ing about the aerodrome which was generally in vogue at the Blériot Schools before the war. On this machine the pupil can be loosed off alone immediately after preliminary explanation with comparatively no risk and at the same time he would get used to controlling his engine have plenty of practice in the use of that important control the rudder and lastly but not least he would have to be left to his own resources, use a little initiative and get used to the noise and wind from his motor. This type of machine might be modified in such a way that the other controls might be brought to play an active part in piloting the "penguin" over the ground. The whole body and wings might be supported independently of the landing chassis (or rather the rolling chassis) in a sort of gimbals so that it could be banked and elevated by the control lever whilst running along or turning. I think an hour's taxi ing on a machine of this type would as a preliminary be of more assistance than the same amount of dual control as the pupil would know at least more about the use of his rudder.

The best type of airplane to use for instruction in actual flying and the question as to whether it should be stable or not is a very debatable point. I do think however that the less efficient within certain limits the early training machine is the better and sounder will be the elementary knowledge and experience gained by the pupil. Such experience is likely to be very valuable when, later in his career, he is confronted with engine failures or similar predicaments where his reserve of engine power will no longer cover up his multitude of sins in piloting. To illustrate this point, let us assume that there are two pilots A and B. A has qualified for his Aero Club Certificate on a box kite i.e. early Henry Farman type biplane fitted with 50 h p Gnome. B gets his certificate on a much more powerful machine one that can climb quicker and can even be turned and climbed a bit at the same time. He knows this is so because he has done it on his last flight. But A finds that to get round really comfortably on his he feels compelled to drop the nose a little, as it feels a little sloppy otherwise. At a later date, on valuable service machines both A and B have engine failures. A lands successfully, B crashes badly through turning too flatly. A has learned from the beginning that he was always on the safe side in dropping her nose a bit on a turn. B always thought it unnecessary.

Personally I do not think that the stable machine is the best for training. If it is considered so on the score that once in the air it will look after itself and so reduce the chances of the pupil crashing, then we have only to assume for the sake of argument that a self landing training machine has been devised that will automatically land itself correctly do away with the smashes on landing and ultimately with a few more improvements all the pupil need do would be just to sit still and take the air as everything would be done for him but after many hours of joy riding on this super school machine he would have learned very little about piloting. For securing Aero Club Certificates for pupils at so much a head as a commercial proposition this sort of machine might be excellent but the unstable machine should be used as the basis of training to get the best results in the end.

The Use of Instruments for Training

I now come to another question, over which there is a deal of controversy. It is the use of instruments for training. I consider instruments as valuable accessories to any machine but only under certain circumstances are they necessities and in training they should not be regarded as indispensable. It is the wrong system in my opinion, for the pupil to be made to rely on them too much. Although flying is largely a mechanical procedure there is a tremendous lot of the personal sensation and feel that the pilot should acquire which, when once acquired will take the place of practically any instrument devised. For instance could an ice-skater learn to do the outside-edge merely by looking at a bubble of a spirit level fixed in front of him? I should say no but once he had acquired the feeling that he had correct balance, which only practice can give, he will make his sharp turn on the outside-edge at the correct angle better than any instrument could show him. Therefore I say let the pupil acquire without delay that naturally instinctive feeling so absolutely essential for a good pilot. Whilst he is taught to rely on his instrument too much to climb turn or even try and land he will be long if ever in acquiring the art that will make him independent of instruments.

Personally I seldom use an instrument as an assistance to piloting. Do not assume that I am sneering at instruments. In fact, as I have stated, there are times when they are a necessity. In fact I am going to suggest that one more instrument be fitted as a standard equipment an instrument to reduce the risks connected with flying in clouds.

Flying Through Clouds

It may not be generally known that there have been such a large number of fatal accidents during the last three years entirely due to flying through clouds and I consider this subject wants going into pretty carefully. The accidents to which I refer have not been questions of a want of height. The machines have become hopelessly out of control. I will give you an instance which happened to myself a few weeks ago in the West of England. You will then realize why I consider this is a serious matter requiring particular attention. I set out on a very cloudy, windy day to do a test climb to 10 000 feet on a late type two-seater. I had so often on previous occasions succeeded quite comfortably in reaching this height in spite of cloudy overcast days by pushing up through the clouds usually only a matter of a few minutes, into bright sunlight and the bluest of skies and after reaching the desired height coming down again through the clouds, being flown by compass and time. On this particular day however the wind was very gusty and on reaching 1,200 feet we got into a dense cloud and but carried on to beyond 5 000 feet still in the cloud when the compass apparently began to swing (really it's the machine that begins swinging not the compass) and efforts to check the compass had the effect of causing it to swing more violently in the other direction. The air speed then rushed up far beyond normal flying speed all efforts to pull her up checked her only slightly, then the rudder was tried back went the air speed to zero, there was an unusual uncanny feeling of being detached from the machine and I knew her to be literally twiddling about in the clouds. All efforts to settle down again to a straight flight seemed to be unavailing until we emerged from the cloud very nearly upside down. Assuming control again was then an easy matter. This sort of thing has happened to me more than once, and, in the Flying Corps vernacular, "it puts the wind up you," and it has happened many times with other pilots. In some cases they emerge from the clouds in a spin others are known in which the planes have collapsed under the strain of the sudden pull up from the vertical nose-dive. A few days ago a squadron commander told me that on one occasion when in France everything loose in his machine fell out whilst in a cloud. A week or so ago, on the South Coast, a machine disintegrated in a cloud and the main planes landed half a mile from the body. From my own experience this is a very unpleasant state of affairs, and in consequence I avoid clouds when possible. Let us try and examine the cause of this. First of all you must realize that in a cloud you see nothing whatever but your machine around you. There is no fixed point visible. The only means by which you can tell if you are flying in a straight course is by your compass and your air speed. The compass should give you your direction horizontally, your air speed your direction vertically. The first thing that happens and very readily too if windy and bumpy is that your compass card will begin to move slightly. It really appears to you that the compass was suddenly affected by the cloud and you are still flying straight ahead. How often you hear a pilot say that as soon as he got into a cloud his compass started spinning. The moment the compass starts moving it requires extremely delicate ruddering to get it back to a steady position, in fact one invariably over-corrects the compass movement and so the trouble begins. Once the compass starts on a good swing I have found it nearly an impossibility to get it steady again until out of the cloud. Before your compass starts to move your machine has already started to turn. You rudder the opposite way to check it, over-correct it and turn sharper the other way on to a bank turn then the nose drops and the speed goes up. Pulling back your elevator lever has little or no effect for if you are banked above an angle of 45 degrees the elevator becomes the rudder. All this occurs without the pilot being in the least bit aware of the position that his machine is taking relative to the ground. The instruments available are of little service once he loses his control.

Of what use is his air speed indicator to him indicating 150 m p h if the machine is on a spinning spiral and he imagines that he is merely descending too fast on a steep straight glide? He naturally tries to pull up but with no effect. The bubble does not help him as centrifugal force will send that anywhere. It may be argued that if a stable machine is left alone under these circumstances it will right itself eventually and assume a normal glide. It very likely would if the pilot could steel himself to let it entirely alone, but before it did so it would have to be left to do a sheer vertical nose-dive for some moments and in these days of big weights and little head resistance one is liable to attempt to pull out too suddenly from the dangerous high rate of speed attained on this dive. What I want to see fitted is an instrument which will show a constant vertical or horizontal line and be independent of centrifugal force. I have no ideas upon the subject nor suggestions as to how this is to be brought about unless something in the nature of a small gyroscope driven by an air-screw could be employed in some way to meet the requirements of flying in clouds, but until something is marketed so that the pilot can see a fixed line, I think we shall continue to have accidents from this cause.

METHOD USED TO CONCEAL AUTO MACHINE GUNS FROM HOSTILE AIRCRAFT

Flying at Great Altitudes

There are lots of other points that I should like to touch upon, but as my time is getting short I shall now deal with the subject of flying at great altitudes as I have found it. The most marked development in the modern machine is its extraordinary capacity for climbing to a great height in a short time. At the beginning of the war the average height flown on active service was 4 000-5 000 feet simply because few of the machines then in use with the impedimenta carried could get much higher. To-day a height of 20 000 feet is, I believe, on certain occasions reached, and it is fairly certain that if progress continues at its present rate heights a great deal beyond this figure will be reached as a usual thing. These great altitudes bring forward many difficulties which will have to be seriously considered. The first trouble in the winter will be the extreme cold to which the occupants will be subjected unless they are protected by special cowling which will gather in the warmth given off from the engine. This to a certain extent, is the natural advantage obtained in the tractor. The question of the difference in the comfort of machines in this respect was shown to me in a very marked manner last winter. I was testing the fall off of engine power at a height on a tractor two seater in which it was specially arranged that the warm air from the radiator and engine passed along the body to the pilot and then to the passenger and although at a height of over 21 000 feet with the thermometer below freezing at ground level, I did not suffer in the least from the cold neither did my passenger, who sat behind complain until we shut off to descend. As a contrast to this a few days later I was on a single seater at an altitude of 17 000 feet and although it was a tractor with a rotary motor, I suffered intensely from the cold, and became so numbed that my vitality must have been something akin to a dormouse under the snow, and in spite of being well gloved I had frostbitten finger tips which pained for many days afterward. Surely this is a very inefficient state for a pilot at the front to have to take on an air fight or other exacting work? Put two pilots up to a great altitude one kept well warmed and comfortable the other half dead with the cold and it would be easy to surmise which would be most likely to do the best work.

I really believe it is more by accident than design that the pilot or passenger have benefited at all in the past from the heat of the engine, with the exception perhaps of the late S. F. Cody's machine. He purposely placed the radiator of his pusher in front of the pilot to keep him warm. I know from my experience when flying in France in the cold weather that the discomfort owing to the extreme cold became intense when flying only at 6 000 feet on a two or three hours' reconnaissance flight. This is a point to which designers should give attention especially as machines are now easily capable of reaching great heights. During summer weather conditions would probably be tolerably comfortable, but in winter it would be well nigh impossible unless better arrangements are generally made.

Cold also affects the engine pretty seriously. This is more noticeable with the water-cooled type. Unless some provision is made for blanketing the radiator surface at heights it becomes far too cold for efficient running. Cases are known of the freezing of the water system on a descent from a great height, with pretty serious results to the engine, as well as the difficulty of getting the engine to run again efficiently through being too cold to effect a landing. In the future war machine the pilot must have a very wide range of control over the water-cooling system.

Effects Due to Flying at High Altitudes

I will now touch lightly on effects that I have experienced on high flights. I have found the effect of high, i.e. rarefied, air to be felt slightly at about 10 000 feet increasing with the altitude. Breathing becomes affected, respiration shorter and quicker there is a curious oppressive sensation and a bulging feeling in the head until the height of about 20,000 feet is reached. I am told by a medical friend who has made rather a study of the subject that there is always a risk of a sudden collapse, and oxygen should be used whether the aviator feels fit or not. Of course, the effect felt varies considerably with individuals, and with the state of one's health. About 18 months ago I suffered slightly with my heart, and found I could not get very high without feeling giddy and after returning from a flight to 12 000 feet I had palpitation which lasted until the following day. In consequence I had to abandon high flying until treatment got me fit again. This year I have made a number of high flights and have felt no ill effects whatsoever; in fact, I find the more one gets accustomed to going up high the less the effects are felt. I am told that this also is the case in mountaineering. I can remember the unpleasantness of my first flight to 15 000 feet. It was very marked, especially the pain experienced in the drum of the ears on descending. The fact that a flight now to 21 000 or 22 000 feet does not have so much effect I put down entirely to acclimatization. I use oxygen as a precaution when ascending beyond 20 000 feet for the previously mentioned reason. A small bottle is carried, fitted with a special reducing valve, which is fixed in the body within easy reach of the hand. No special regulation is required as it is set to pass only the necessary amount of gas into the face mask which acts as a mixing chamber, with its inlet and outlet air valve. The apparatus weighs 10 lb. and contains sufficient oxygen for one hour's continuous use. After reaching 20 000 feet I find it is only necessary to use the oxygen intermittently and accordingly I simply hold the mask after turning on the gas over the mouth and nose and take a few breaths of it, perhaps every half minute. The effect on me is remarkable, most of the oppressive feeling vanishes and, excepting for the unpleasant bulging feeling of the head, which you experience with a bad cold the sensation is one of suddenly being again at ground level. The only after-effects upon landing from these high altitudes are that you seem to acquire a pretty good thirst due, I suppose, to the use of oxygen. If the speed of climb continues to improve at the rate it has for the past three years, it looks as though aviators will become subject to what is known as "Caisson Disease," due I am told to the sudden reduction in atmospheric pressure, such as divers are subjected to when they come to the surface from a great depth, owing to the nitrogen which has been absorbed by the system in proportion to the atmospheric density, forcing itself too rapidly at any lower pressure from the system.

There are many other points that I intended touching on in this paper but I find that to do full justice to the subject it would occupy considerably more than the limited time at my disposal.

The Cleveland Aero Engine

The following interesting details of the new Cleveland engine have been supplied by the manufacturers

The requirements of an aviation engine today seem to be maximum possible power which can be crowded into certain limited space without excessive weight, economy of operation in regard to both fuel and oil, reliability for extended periods of time, and lightest possible weight. In developing the Cleveland aero engine these points have been considered and incorporated in its design.

There seem to be limiting speeds beyond which a propeller loses some of its efficiency and absorbs a certain amount of power from the engine which it cannot convert into effective thrust These limiting speeds are considerably below the practical maximum rotary speeds for the high-powered gas engine These being the facts, the logical solution of this problem is to design a machine for high piston speeds and gear down from the crankshaft so that the propeller makes a lesser number of turns. In any ordinary type of fixed cylinder machine this is accomplished through reduction gears which compare in an airplane to the transmission in a car in other words, becomes a separate and intermediate unit

The Cleveland aero engine has incorporated these speed-reducing gears in the design of the engine as an integral part of the machine, practice having proven that it is entirely feasible, especially in the smaller types of engines, to operate the engine at twice the propeller speed or more. In this engine the propeller speed is exactly one-half that of the crankshaft, and the parts are so arranged in the design that no separate camshaft is required eliminating in itself a number of parts ordinarily used and thereby also reducing weight

In order to obtain the highest practical economy of both fuel and oil, water cooling is used This makes possible carrying the cylinder compression much higher than would be practical by direct air cooling, which in itself makes for much greater fuel economy. The comparatively low temperatures of cylinders and pistons conserves the oil supply and assists in making possible a larger radius of action on a given weight of oil

In connection with the question of lubrication, another feature of this motor is worthy of attention. There are no plain bearings in the crankcase structure of this engine which ordinarily require pressure oiling systems of extremely high efficiency in order to prevent over heating of these bearings under the heavy duty required of them This being the fact, special methods for cooling lubricating oil become unnecessary, thereby saving an additional weight and complications required for such cooling In addition to that, the all ball-bearing construction makes possible the delivery of a far greater percentage of the indicated horsepower through the propeller

The entire design has been worked out with a view of developing a machine specially suitable for working into stream line body form. The machine is compact, and its parts so located that the operator has all features usually requiring attention immediately in front of him so that their operation may be watched and adjustment made even in flight as might become necessary

From a thermal standpoint, the machine is highly efficient It is also capable of developing practically the maximum amount of horsepower per inch of piston displacement The shape of the combustion chambers and the details of cylinder design and assembly make these things attainable

The Akimoff Dynamic Balancing Machine

This apparatus is of interest to engine builders. It is based on the principle that lack of dynamic balance (in a statically balanced body) is due only to a centrifugal couple acting in an axial plane. This can only be balanced by introducing another centrifugal couple of the same magnitude but of opposite sign, in other words by drilling two holes or adding two weights.

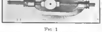

Fig 1

The apparatus consists of a clamp (Fig 1) very carefully made and calibrated which is firmly secured to the outer end of the shaft of the body the other end of which is fastened in a chuck of a plain engine lathe (Fig 2) The end carrying the clamp is resting on the rollers of a yielding support, firmly secured to the shears of the lathe and provided with an ordinary dial gage indicator and that is all

By trial the clamp is adjusted in its proper position on the shaft throwing it off center through a certain amount, thus

Fig 2

an unbalanced centrifugal force is produced acting directly upon the body itself, and in consequence of the reaction of the fixed end of the shaft, such an unbalanced force can be made to counteract the disturbing unbalanced couple of the body

All that has to be done is to read the off center displacement of the clamp and to take into account the distance of the clamp from the chuck, and an immediate reference to specially constructed tables or curves gives a quick answer as to what to do, how and where to drill, etc Fig 3 represents a data sheet, referring to a four cylinder crankshaft of a well known car

These clamps are standardized and range in 1 in intervals like ordinary micrometers for instance the smallest size is 0 to 1 in the next size is 1 to 2 in etc Several sizes are carried in stock while special sizes can promptly be made to order, there being absolutely no limit to the size in which a clamp can be made

The yielding supports are so proportioned that one size can take care of a great variety of shaft diameters.

This equipment need not be operated at excessive speeds during the tests, the results are quite independent of the r p m An average mechanic can learn the operation in about two hours. In two days he becomes an expert he has no calculations to make and must but follow the easy instructions and charts supplied with each device

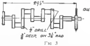

Fig 3

$640,000,000 Aviation Bill Passes House

Gas Plant at Langley Field

Contract has been awarded at $370,856 for constructing and equipping the hydrogen gas plant of Langley Aviation Experimental Station and Proving Grounds at Hampton Va where the Government will expend millions of dollars The Improved Equipment Co of New York received the contract and contract for building a dock and railway to connect the aviation plant with Back River has been awarded at $22 000 to the Vaughan Construction Co of Stowsville Va

The gas plant will include these features Hydrogen generating building, flash charging building steam boiler plant blue gas generator No 8 horizontal positive-pressure blower for blue gas, blue-gas exhauster blue-gas holder of 25 000 cubic feet capacity blue gas scrubber, blue-gas meter multiple vertical retort type hydrogen furnace with hydraulic main and scrubber hydrogen gas exhauster hydrogen-gas holder of 200 000 cubic feet capacity for 15x12 foot oxide purifiers for blue gas hydrogen gas relief holder of 5000 cubic feet capacity, four 10x8-foot hydrogen gas purifiers two steam hydraulic elevators capacity 3500 cubic feet per hour when operating 22 hours daily, with provision for increasing to 7000 cubic feet per hour

The Aviation Bill, carrying an appropriation of $640,000,000 for Army aeronautics, was passed by the House of Representatives July 14, without a dissenting vote, and with very brief debate

The measure will now come before the Senate, where its passage without serious opposition is anticipated

$45,000,000 Asked for Naval Aeronautics

The Secretary of the Navy has recommended to Congress the appropriation of $45 000 000 for naval aeronautics in addition to the amounts already made available

Discussing the need of this appropriation Secretary Daniels said

The value of aircraft has been abundantly demonstrated in the present war, and the Navy is making efforts to build up an air force of sufficient size to operate as scouts from naval vessels to patrol the waters off the extensive coasts of the United States and our insular possessions, and also to cooperate with naval forces abroad in anti-submarine warfare

"The $45 000 000 recommended will be required to maintain and expand the existing schools and stations to establish new stations and training schools and to purchase the necessary aircraft—sea planes, dirigibles and kite balloons—for use on the high seas and from coastal stations at home, and in cooperation with our allies

The additional personnel required for the operation of the naval aircraft is being enrolled in the Naval Reserve Flying Corps. Applications continue to be received in large numbers, and the successful candidates are being taken into the service as rapidly as possible"

Radio Division Established

A Radio Division of the Office of the Chief Signal Officer has been established This office will handle radio matters for both the Aviation Section and the Signal Corps proper

Major Nugent H Slaughter U S R. has been designated as the officer in charge of this division with headquarters at 1710 Pennsylvania Ave Washington, D C Capt Clarence C Culver has been transferred from the Aircraft Engineering Division to the Radio Division.

Spokane Plans Landing Stations

Spokane is to be one of the first cities in the United States to lay out and maintain regular landing stations for passenger, freight and postal airplanes.

The selection and assignment of these stations will be one of the first duties of the new city planning commission, the establishment of which will be voted upon at the November election

Commissioner C M Fassett has called attention to the necessity for such stations in view of the rapidly increasing use of aircraft

"It's a logical duty for the commission to plan such stations" he declared

Traffic After War

The end of the war will see the United States, not only with thousands of planes, but with such facilities for the rapid turning out of new flying machines, that private planes will become common, Mr Fassett believes

City planning committees which are at work all over France getting ready to rebuild German-destroyed cities and towns, are paying special attention to the selection and adaptation of tracts of land for airplane stations. The French example, Mr Fassett says, should be followed at Spokane

Present apparently available locations in Spokane include the park board's property between Mission, Sinto, Cook and Regal the up-river golf course and some raw land southwest of the Northwest Boulevard

The preparation of the landing stations is not a complicated business The land is cleared of all big rocks huge markers are laid out to guide aircraft approaching the city Illumination is provided for night work and workshops, where machines may be overhauled and repaired, are constructed and equipped

"All America" Airplane Engine Ready for Tests

Announcement that the new airplane engine with which America's air fleet will be equipped has been built and is ready for final tests has been made by Brig Gen. George O Squier, Chief Signal Officer, testifying before the Military Affairs Committee of the House The committee was considering the Administration bill for the organization of the first contingent of the air fleet.

The new engine will be an American development, though its designers have had the benefit of all information and experience of our allies abroad. Howard Coffin of the Council of National Defense one of the most successful automobile engine designers in the country, is understood to be largely responsible for the new engine, which is said to promise a big advance in sustained flight and weight carrying power

Making Propellers in a French Aviation Camp Near Salonica

Testing Laboratory for Engines

The National Advisory Committee for Aeronautics authorizes the following

At a recent meeting of the subcommittee on power plants of the National Advisory Committee for Aeronautics, preparations were made for the development at the Bureau of Standards of a laboratory for testing aircraft engines under conditions of altitude and temperature similar to those encountered in flights at an altitude of 20,000 feet or more The laboratory and its experimental equipment will be organized under the auspices of the Advisory Committee and the investigations will be directed by the subcommittee on power plants.

The special immediate purpose of this proposed equipment is the prompt testing out of the so-called "All America" airplane engine, now under development in order to be able to immediately put it under controllable conditions corresponding to any altitude and any atmospheric conditions which would be met in the air

Ground School Graduates

With the graduation of 142 candidates for appointment as aviation officers it became evident that the plans of Brig Gen George O Squier, Chief Signal Officer are working out successfully with respect to personnel. Eleven days before any of these candidates entered the schools of military aeronautics assurances were given that 120 students would be graduated at the ground schools at Cornell and other colleges on July 14. This number was exceeded by twenty two.

There were graduated from the aviation schools at the University of Illinois, twenty five; the University of Texas, nineteen; Cornell, twenty-eight; the Massachusetts Institute of Technology, twenty three; the University of California, twenty four, and the University of Ohio twenty three students. There are now more than 1,200 candidates undergoing training at these schools and 100 are being trained at the ground schools which were opened at Princeton and the Georgia Institute of Technology on July 2. The six ground schools first named are expected to graduate an average of 150 a week from now on, and beginning five weeks hence when Princeton and the Georgia Institute also will begin to turn out graduates, the total for the country will be swelled to 200 a week or a prospective 10,400 graduates during the next year.

The men who have done no flying but who have gone through an intensive training in all ground work up to the point of flying have been assigned to the aviation schools at Chanute Field Ill., Selfridge Field near Mount Clemens, Mich., San Diego, Cal., and Mineola L. I. After successfully passing examinations as fliers they will be commissioned as first lieutenants in the Aviation Reserve Corps.

Flying to Begin This Week at Rantoul

Flying will begin this week on the first of the big new Government aviation training fields at Rantoul Ill. Howard Coffin chairman of the Aircraft Production Board of the Council of National Defense announced on his return from a visit to the training fields now under preparation at Rantoul, Dayton Ohio and Mount Clemens Mich. There will probably be twenty fliers on the ground at Rantoul this week and all three fields will be completed by July 15.

The construction work on Chanute Field at Rantoul has broken all records. Mr Coffin said "A half million dollars worth of buildings have been put up practically within a month. They form a village a mile long and the speed with which they have virtually sprung out of the ground has been deeply impressive. A few weeks ago the big mile square space was simply a collection of cornfields.

No Disagreement Among Men

The explanation for the speed with which the work has been done is the spirit which has filled the men engaged in it. Union men and non union men are working side by side in the effort to advance the national interest. The only outward distinction is that the union men are working behind a big American flag which is advanced as the job progresses. The sole idea which has occupied the minds of the workmen has been the desire to break all records on this war work. There are 2,000 men on the job and there has not been a disagreement or row of any kind since it started. I was impressed with the fact that these men were doing their part in the Nation's service just as earnestly as though drilling in the ranks with guns on their shoulders.

Work on Other Fields

"There are 1,000 men working on the Wilbur Wright Field at Dayton and 2,000 on the Selfridge Field at Mount Clemens. The Dayton field is the most impressive as it is more than twice the size of the others. It is intended to accommodate four squadrons instead of two and is about 1½ miles wide and 2½ miles long. Orville Wright is actively superintending the work at Dayton.

The preliminary training schools now training cadets will be prepared to send quotas of students to the training fields as soon as the fields are ready and the work will be in full swing by the last of July. Arrangements have already been made for training planes and although the full quota of machines will not be available by the 15th the shortage will not be serious.

Realize Size of Task

"The Aircraft Production Board has no illusions as to the size and character of the job before it," a statement issued by the Board the other day says, "but the whole task is one of industrial organization for quantity production, and in this we Americans are above all other nations fitted by experience and tradition to break records. The new permanent aircraft exhibit should furnish a valuable aid to the process of familiarizing the industry with the task and organizing for its accomplishment."

Marine Corps Aviation Station

A camp has been opened at the Philadelphia Navy Yard for the new marine aviation corps.

The corps is commanded by Capt A. A. Cunningham and he is assisted by Capt F. T. Evans, Capt W. M. McIlvain, Lieut Edward Chamberlain and Lieut W. F. McCaughtry. There are 178 enlisted men in the organization recruited from chauffeurs, engineers and others familiar with delicate machinery.

This Photo of a Nieuport Scout Shows Clearly the Arrangement of the Bracing Wires the Two Flying Wires Coming to a Point at the Body Hinge and the Two Landing Wires at the Junction of the Outer Strut

Spark Plugs for Airplane

To find an American-made spark plug that would satisfactorily take the place of the foreign plug heretofore used in the airplane engines which they are building for the United States and certain allied governments the Hall-Scott Motor Car Co. of Berkeley, Calif. has just completed a series of exhaustive tests. After what it terms the most rigid tests any American plug has ever withstood the company gave an order for a quantity of Rajah Rajite waterproof plugs to Hughson & Merton Coast distributors. In the test the Rajah plug was run for fifty hours wide open upon one of the Hall-Scott 170-h.p. engines.

The tests just concluded have extended over a period of eight months during which time every available American plug was tested under conditions for safety's sake even more severe than prevail in actual airplane use.

Sturtevant Co Assisting in Ground School Work

W. L. Barrett of the Sturtevant Aeroplane Co. is lecturing at the School of Military Aeronautics of the Massachusetts Institute of Technology, on the transportation of machines.

One of the mechanics from the same company is giving instruction in sail making and splicing and the company is giving valuable assistance to the school in many other ways.

Dayton Wright Expanding

Official announcement has been made that the Dayton Wright Airplane Co has taken over the Moraine City factory of the Domestic Engineering Co for production of airplanes for the United States Government.

An initial order of 500 machines to be completed by the end of the present year, has been received with additional orders expected to follow.

Several hundred acres surrounding the factory will be made into an aviation field, for testing machines. One new building will be constructed at once for assembly purposes.

These industrial undertakings will give employment to thousands of men women and children. Twenty minute service will be given between Dayton and Moraine City for people employed at that place.

Curtiss School Record

The Curtiss Aeroplane Co. advise that their instructors at the Atlantic Coast Aeronautical Station during the past few months have flown Army Reserve Corps men a total distance of 104,000 miles without any serious accident to the Corps. This is a creditable record speaking volumes for instructors machines and for the safety of flying.

The Eyes of the Guns

THE Great War has shown clearly that the observing airplane is not all-sufficient for the artillery.

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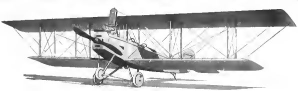


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Aerol is a practical oil because it is easily handled, flows easily. This feature is of practical utility where oil is drained off and cleaned out frequently. Also, where external feed systems are used.

Aerol is a quality oil—a fine lubricant, but not extravagantly so—and a practical lubricant because it meets the requirements of practical usage at a reasonable cost. Full details, characteristics and tests will be furnished to government officials, aeroplane manufacturers or others interested in the subject of aeroplane motor lubrication.

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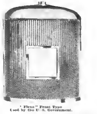

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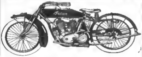

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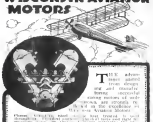

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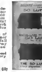
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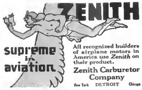
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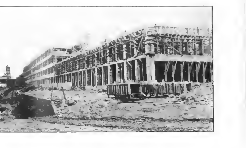

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